CAN A MILK-TO-FEED PRICE RATIO FUTURES CONTRACT HELP FARMERS? A STUDY BASED ON NEW YORK DAIRY INDUSTRY

A Thesis

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ABSTRACT

Dairy producers confront increasing price risks from both inputs and outputs as the prices of milk, corn and soybean become more volatile in recent years. These risks significantly affect dairy producer's profit margin. This thesis proposes two futures contracts – milk-to-corn price ratio futures and milk-to-feed price ratio futures, both serving the purposes of protecting profit margin for dairy producers with only one hedging position.

A theoretical framework is developed in which the stochastic processes and specifications of the two futures contracts are constructed and a simple farm profit model is established. Six scenarios of dairy farm profits are considered in this thesis. Optimal hedge ratios are derived based on commodity price levels for each hedging strategy.

To examine the effectiveness of the proposed price ratio futures contracts, an empirical analysis is applied to a sample of 36 New York State dairy farms from 1996 to 2010, assuming each farm had routinely hedged. By qualitatively comparing the mean and variance of the calculated farm profits under the above six scenarios for each sample farm, milk-to-corn and milk-to-feed futures contracts would have been effective in managing price risks and protecting profit margin based on the sample.

BIOGRAPHICAL SKETCH

Yidi Xia was born in China in 1987. She spent her happy childhood in the suburbs of Tianjin as the only child in her family. In 2005, she finished high school at Tianjin Foreign Languages School as a science student. In July 2009, Yidi graduated from Fudan University in Shanghai with a Bachelor degree in Economics. Back then, she decided to go straight to graduate school in the United States to pursue higher education in the economics field.

Yidi began her study at Charles H. Dyson School of Applied Economics and Management in Cornell University in the fall of 2009. After graduation, she will continue her pursuit as a sports lover, a world explorer, a society contributor and a life believer of happiness.

Delicate to *Dairy Farmers and Agricultural Development*

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I could not have gone this far without the support from many people, to whom I would like to show my sincere gratitude and appreciation.

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Chapter 1 INTRODUCTION

1.1 Problem statement

Dairy producers confront various sources of risk. Among those, the uncertainty associated with the future cash price of a commodity is known as price risk. Dairy farm profits are not only affected by the price risk from the output milk price received, but also influenced by the volatility in input prices. Dairy feed, which mainly consists of corn and soybean, is one of the most important inputs for dairy producers. As a non-storable commodity, there could be large change in milk prices in reaction to changes in market fundamental. On the other hand, high costs and high volatility of feed prices are threatening the survival of dairy farm business.

The prices of milk, corn and soybean[1] have become even more volatile in recent years, posing increasing price risks and ultimately business survival risk to dairy producers. As shown in Figure 1, 2 and 3, New York State all milk prices have not increased much for the past 15 years[2] while corn and soybean prices have soared since 2006. The fact of rising feed costs shrinks the profit margin for dairy producers in New York. Both the frequencies and magnitude of fluctuations for the rolling twelve month

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[1] Corn, soybean and alfalfa hay prices are converted from dollar per bushel to dollar per hundred pounds in this thesis. According to U.S. commercial bushel sizes, corn has a standard of 56 pounds per bushel, soybean 60 pounds per bushel, alfalfa hay 2,000 pounds per ton.

[2] The mean and standard deviation for monthly New York State all milk prices from 1996 to 2010 is $15.29/cwt and $2.59/cwt respectively, for U.S. average corn price is $4.86/100 lbs and $1.65/100 lbs, for U.S. average soybean price is $11.51/100 lbs and $3.69/100 lbs.

average and standard deviation for milk, corn and soybean prices have increased over time, which demonstrate the higher volatility thus the higher price risks on both output and input sides for dairy producers. As a result, feed and milk hedges must be considered in conjunction in order to effectively manage margins of dairy operations in today's volatile price environment.

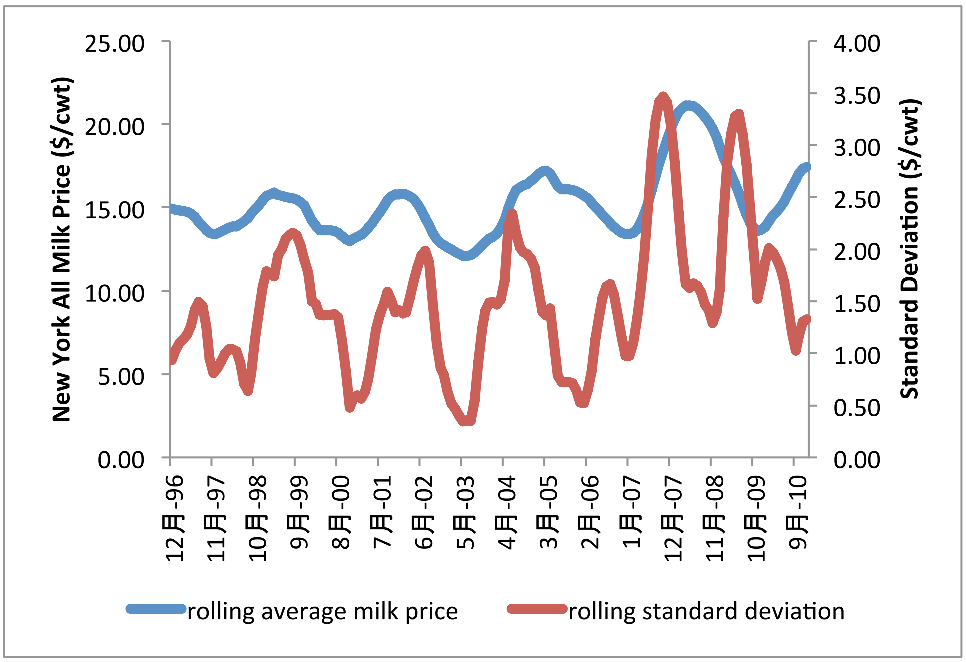

Figure 1 Rolling 12-month Mean and Standard Deviation of New York Monthly All Milk Price from 1996 to 2010

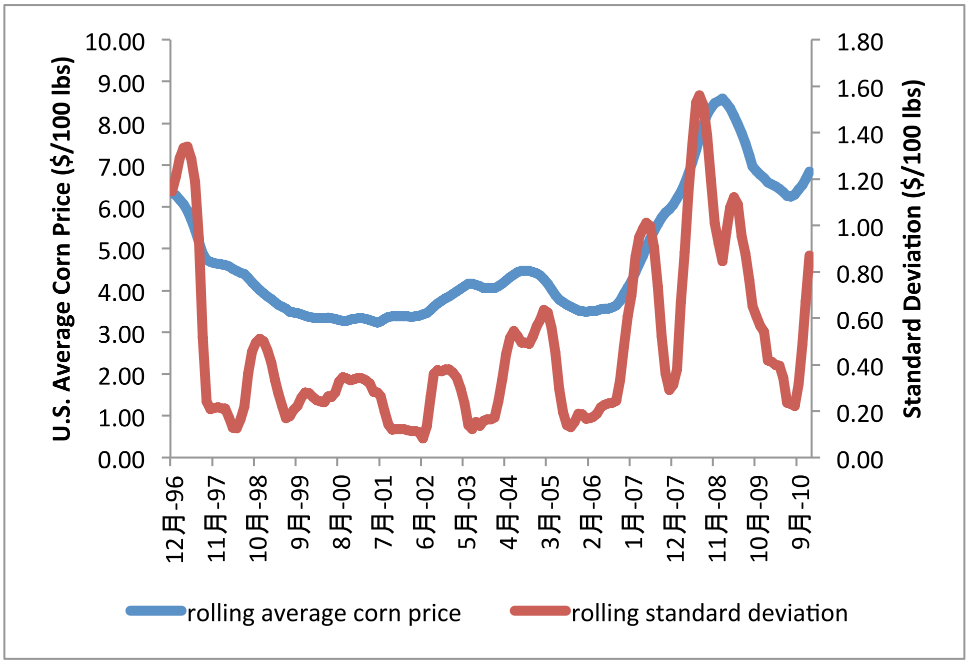

Figure 2 Rolling 12-month Mean and Standard Deviation of U.S. Average Monthly Corn Price from 1996 to 2010

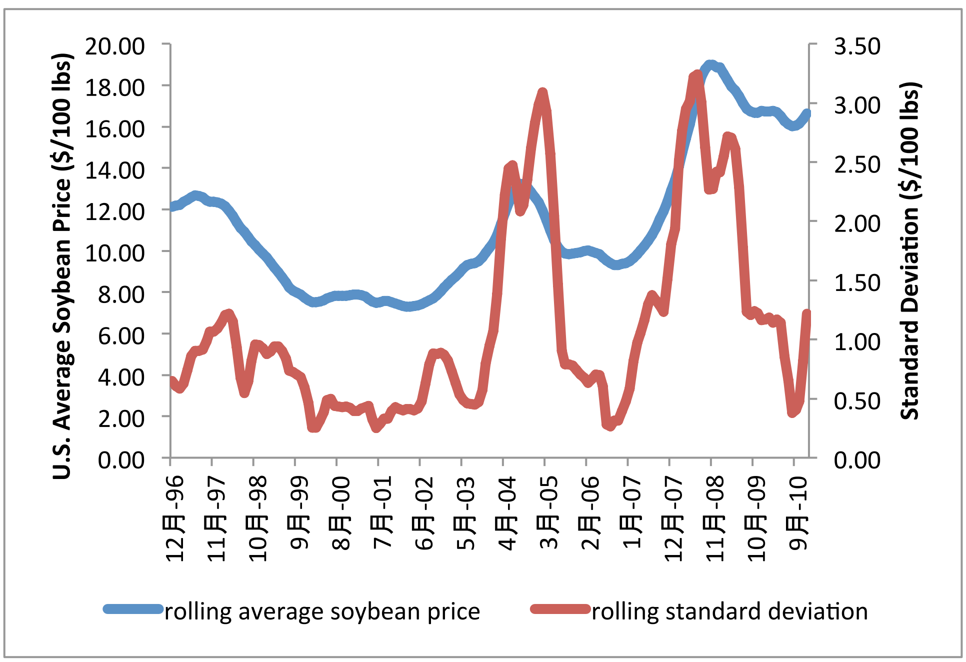

Figure 3 Rolling 12-month Mean and Standard Deviation of U.S. Average Monthly Soybean Price from 1996 to 2010

The widely used risk management tools for dairy farms against the price risks include forward contracts, futures contracts and options. This thesis focuses on managing the volatility of milk prices and purchased feed prices for dairy producers using futures contracts.

A dairy producer would want an increase in milk prices and decrease in feed prices. Since the cash and futures prices for the same underlying commodity always move in the same direction, dairy producers could reduce the risk associated with a price decline in milk prices by taking a short position in milk futures. If milk prices decline, the producer could balance the loss in the cash market by the gain in the futures market. The loss and gain would be equal in value if there is no basis risk and transaction costs are ignored. Similarly, dairy producer could take a long position in corn or soybean futures to minimize the risk associated with a price increase in feed prices.

If the dairy producer's objective is to protect the profit margin, he or she could lock in the dairy income over part of the feed costs by taking a short position in milk futures and long position in corn or soybean futures simultaneously. This strategy would require estimates of the simultaneous hedge ratios for two or three hedging positions which may impose bigger estimation errors. Dairy producers also need to track the cash and futures market of milk, corn and soybean and may have to adjust both short and long positions upon price changes of one commodity. In addition, the transaction costs associated with this strategy could be pronounced. In the case of sharpened increase in milk futures price and decrease in corn futures price, it is highly likely that dairy producers would not be able to meet the margin calls requirements.

It is important to note in this thesis that presumably dairy producers hedge routinely and do not consider selective hedges, which is a strategy that only hedge when the profit margin is positive. The prices of milk, corn and soybeans may be such that routine hedges would lock in a negative margin, or a margin that would not cover non-feed costs. Thus, routine hedges do not assure a positive return every year though in principle they can reduce the variance of the margin. The limitations of routine hedges are beyond the discussion in this work.

This thesis develops two new futures contracts, R1 and R2, both serving the purposes of protecting profit margin for dairy producers with only one hedging position in futures market. R1 is the milk-corn contract, which is based on the price ratio between one Class III milk futures and one Corn futures contract. R2 is the milk-feed contract, which is based on the price ratio between one Class III milk futures and a combination of Corn futures contract and Soybean futures contract. The weights of Corn futures contract and Soybean futures contract sum up to one and are based on the feed ration of a dairy cow, which will be specified in details in Chapter 3.

1.2 Objectives of the thesis

The development of futures contracts based on milk to corn and milk to feed price ratio are motivated by the soybean-corn price ratio futures trading on Chicago Mercantile Exchange (CME). The CME Group introduced soybean-corn price ratio futures and options as an efficient way to trade on new crop planting expectations. Likewise, the proposed futures contracts in this thesis are designed to serve as a potential simple and efficient alternative to hedge the profit margin for dairy producers. To examine the effectiveness of the proposed price ratio futures contracts in managing price risks and protecting profit margin, farm profits under different hedging scenarios are being calculated and compared based on a sample of 36 New York dairy farms. Accomplishment of these objectives may, to some extent, provide implications on the selection of hedging instruments based on the risk management goal of dairy producers. The various assumptions made for simplification purposes, limitation of data and sample bias should be acknowledged when reaching conclusions from the empirical results.

In order to achieve the general objective above, specific objectives are developed as

(1) Define futures contract R1 and R2 and construct hypothetical historical price series for R1 and R2 based on mark to market nearby futures price ratio. The stochastic processes of R1 and R2 are developed as a foundation for pricing option on ratio futures;

(2) Establish a simple farm profit model that characterizes income from milk sales over feed costs and operating costs. A standard feed costs structure is built based on the dairy feed ration used by USDA. All assumptions made are aiming at singling out the effects of other risk factors but the price risks on dairy operations;

(3) Consider farm profits under six scenarios: no hedging, short Class III milk futures, long corn futures, short Class III milk futures and long corn futures simultaneously, short milk-corn price ratio futures and short milk-feed price ratio futures. Optimal hedge ratios are derived based on commodity price levels for each hedging strategy;

(4) Implement R1 and R2 futures to dairy producers and examine their hedging effectiveness. This is achieved by calculating individual farm profits for each of the six scenarios described in (3) using historical New York State farm data. A comparison is conducted on a farm basis under the mean-variance framework.

1.3 Organization of the thesis

This thesis proceeds in the following manner. The motivation for developing ratio futures and background information on milk-feed ratio are presented in Chapter 2. A literature review is also conducted on behavior of commodity prices, which lays out the assumption for pricing option on the proposed futures. In Chapter 3, a theoretical framework on constructing and implementing the futures contracts to dairy operation is established with a detailed discussion on farm profit model, optimal hedge ratio and basis risk. Chapter 4 describes the data and methods in the empirical analysis of the model. Results are then summarized and discussed in Chapter 5. The last chapter concludes the potential implications and possibility of further research.

Chapter 2 BACKGROUND AND LITERATURE REVIEW

This chapter starts with the motivation for developing ratio futures. An overview of the soybean-corn price ratio futures and options is presented. Milk-feed ratio, used as a profitability measure for dairy industry, is the underlying commodity of the proposed futures contract. Background information is discussed on this ratio. Although this thesis only proposes and analyzes price ratio futures, a literature review is conducted on behavior of commodity prices, which lays out the assumption for pricing option on the proposed futures.

2.1 Futures and options on commodities price ratio

The idea of developing the milk to feed price ratio futures is motivated by the soybean-corn price ratio futures trading on CME.

Soybeans and corn compete for planted acres. As defined by CME, the soybean-corn price ratio futures are based on the price ratio between the referencing soybean futures contract and the referencing corn futures contract. The futures price of soybean-corn price ratio contract is marked to market. The soybean-corn price ratio option is also developed as an additional tool for market participants to trade on the price relationship between corn and soybeans, and the subsequent impact on new crop planted acreage. Even though the trading volume is extremely small and the soybean-corn price ratio as a key factor for planting decision is debatable, it provides the idea of creating futures contract based on the price ratio of two commodities that are both relevant to decision making.

Previous literatures have not been found, to the best of my knowledge, on the discussion of inter-commodity price ratio futures and pricing options on price ratio futures. Options on R1 and R2 futures would provide greater flexibility in managing dairy profit margin. Black-Scholes model commonly used for pricing options on futures is based on the assumption that the underlying futures price follows geometric Brownian motion. This thesis only focuses on the pricing and application of the futures contracts. A brief discussion of the stochastic processes for R1 and R2 futures contracts can be found in Chapter 3.

2.2 Milk-feed ratio

Milk-feed ratio is a common measure to assess the profitability of a dairy farm. According to USDA, the milk-feed ratio is the number of pounds of 16 percent protein-mixed dairy feed equal in value to 1 pound of whole milk. High value for this ratio indicates that feed is relatively cheap to milk and vice versa. The mixed dairy feed for the ratio consists of 51 pounds of corn, 8 pounds of soybeans and 41 pounds of alfalfa hay. The major feed components of corn and soybeans account for 83 to 91 percent of the total ingredients in the rations in terms of value[3]. Thus, hedging with the proposed futures contract R2, based on the ratio of milk price to a weighted average of corn and soybean price, could theoretically lock in income from milk sales over most of the feed costs.

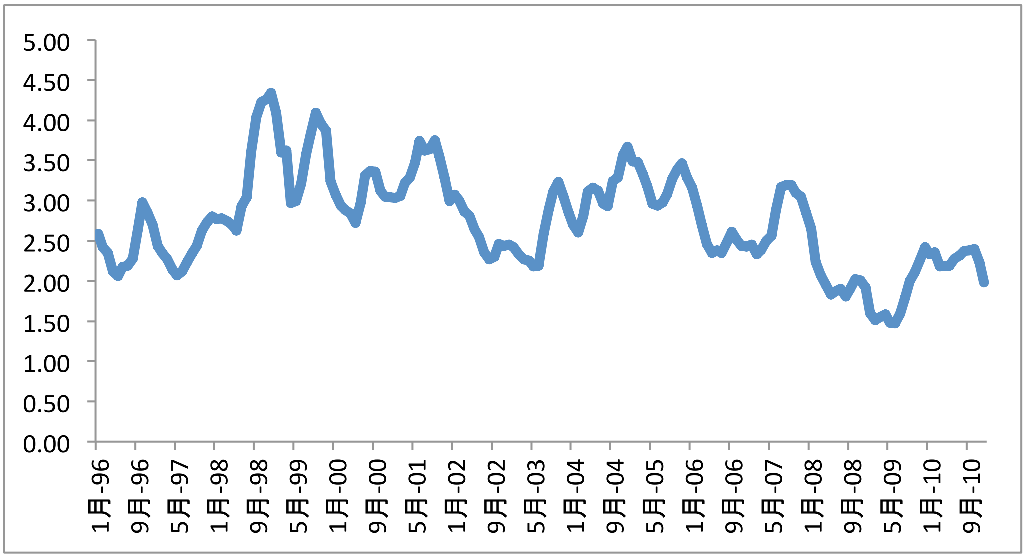

Figure 4 U.S. Average Milk-Feed Monthly Price Ratio from 1996 to 2010

As shown in figure 4, milk-feed ratio has decreased in recent years. This is mainly the result of dramatic rise in feed prices. Low values of this ratio are signs that feed is relatively expensive to milk price. In this case, a relatively lower dairy income over feed costs should be expected. In figure 5, annual U.S. average milk-feed ratio is plotted against the average net farm income without appreciation for the same 79 New York dairy farms from 2000 to 2009. The trend generally shows that when milk-feed

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[3] Source from "Tracking milk prices and feed costs" by Kenneth Bailey and Virginia Ishler, Pennsylvania State University

ratio is low during the year, net farm income is usually low. It provides the rationale of hedging against milk to feed price ratio to reduce the variance of farm profits over time.

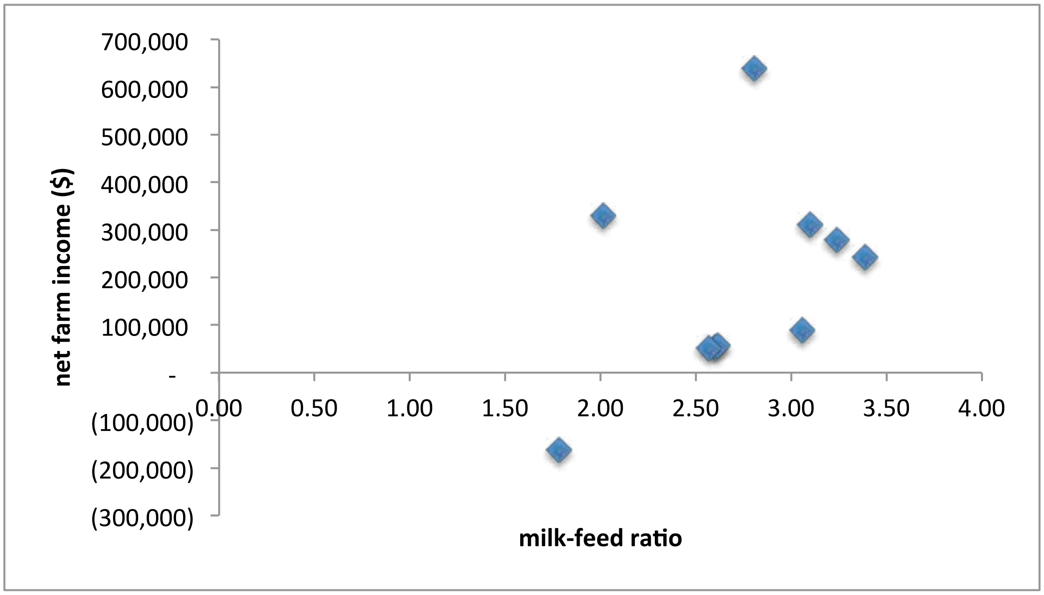

Figure 5 Same 79 New York Dairy Farms Net Farm Income without Appreciation, Annual U.S. Milk-Feed Ratio, from 2000 to 2009

The feed ration used to compute this milk-feed ratio is referenced in this thesis to establish the feed costs structure of the average dairy farms. The applicability and preciseness of milk-feed ratio as a measurement for farm profitability has been debatable. Therefore, the limitations of referencing this feed ration is presented in Chapter 5.

2.3 Behavior of commodity price

This section discusses the progress and limitations with respect to modeling commodity price behavior with a focus on the futures price behavior. Little common agreement has been reached on the generating process of futures prices.

Tomek and Peterson surveys and evaluates risk management on agricultural markets with a review on the modeling of commodity price behavior. In their review, the simplest model states that the price of a futures contract at current time t is the expected value of spot price at contract maturity T conditional on the information available at current time.

$$F(t,T) = E[P(T)|X(t)] \qquad (1)$$

where $F(t,T)$ = price of a futures contract at time t that expires at time T;

$X(t)$ = information available at time t;

$E[P(T)]$ = expected value of spot price at contract maturity T;

This equation implies that the futures price is an unbiased estimate of terminal price. Another model proposes that there exists non-zero risk premium in futures price (Tomek). The risk premium could vary through time.

$$E[F(T)|\Phi(t)] = F(t,T) + \gamma(t,T) \qquad (2)$$

where $\gamma(t,T)$ = risk premium at time t;

However, risk premium may be so small that it could not be found statistically in a futures market.

The central argument regarding the behavior of futures prices lies in whether there is a systematic pattern over time or it simply follows a random walk. As summarized by Cargill and Rausser, much of the investigation on commodity futures prices can be classified into the following results. First, random behavior in futures prices is generally consistent with the “random walk” model while the result was weakened when the sample of contracts was very large. Second, several studies found that substantial profits were possible from simple trading rules in futures market.

Among these studies, Stevenson and Bear used various statistical tests and mechanical filter rules to study the corn and soybean futures price series. The results suggest that the random walk hypothesis does not offer a satisfactory explanation, rather, futures prices move in a systematic manner. On the other hand, Working’s anticipatory prices theory and Larson states that a random walk model is a reasonable approximation to the variation in futures prices over time.

For the purposes of this work, the arguments may not be quite essential as the proposed futures contracts are defined as the ratios of existing futures prices. However, the assumption of futures price behavior is crucial if pricing options on the proposed futures contracts, where the futures price is assumed to follow a random walk.

Models in this thesis assume futures prices to be unbiased estimates. The basic hypothesis of the random walk theory is that price changes occur randomly and are not correlated from each other. The applicability of a random walk is based on the assumption that the futures market fits in the concept of an efficient and arbitrage-free market, that the futures price at a given time reflects all the information available at that time. Time-series of price changes have zero auto-correlations. New information that affects the futures price happens randomly and cannot be predicted in advance. In futures market, the random walk can be expressed as,

$$F_t - F_{t-1} = \varepsilon_t \qquad (3)$$

where F_t is the discrete futures price series, ε_t has a mean of zero and is uncorrelated with ε_{t+k} $(k \neq 0)$. This model simplifies the actual data generating process for futures prices by assuming that the price series behaves as a simple stochastic process.

To describe the random walk in futures price series, geometric Brownian motion with constant drift and volatility is often applied as a standard approach to model time series of financial instruments.

$$\frac{dF}{F} = \mu dt + \sigma dz \qquad (4)$$

where μ is the expected growth rate in the futures price F, σ is its volatility and dz is a Wiener process. This is the underlying assumption when pricing options on futures using the Black-Scholes model. In this work, futures prices are assumed to be unbiased estimates. Thus, the mean of the percentage price change is zero. An implication of unbiasedness from the above equation is that the drift term μ is zero. Turvey (2006) investigates the existence of a geometric Brownian motion in 17 agricultural commodity price time series. The results indicate that the null hypothesis of ordinary Brownian motion cannot be rejected for 14 of 17 series.

Again, this would be crucial when pricing the option on the proposed futures contracts. The work in this paper only focuses on the pricing and application of the futures contracts by dairy producers. The stochastic processes of the two new futures contracts based on mark to market ratios are also developed as a foundation of potential further research.

Chapter 3 THEORETICAL FRAMEWORK

3.1 Introduction

Two new futures contracts, one based on the milk-corn price ratio and the other based on the milk-feed (corn and soybean) price ratio, are introduced for dairy farm profit hedging purposes.

The relative value between milk and dairy feed is the key determinant of dairy farm profit from dairy operations. The feed considered in this paper are corn, soybean and alfalfa hay which are the main grain to feed cows, provide protein and fiber respectively. Corn and soybean futures are also among the most important agricultural commodities traded on CME in terms of trading volume and open interests[4]. Alfalfa hay is not a tradable on CME, thus its costs could not be hedged using corresponding futures. Therefore, only milk, corn and soybean are considered when choosing hedging instruments. The first futures contract R1 is based on milk-corn price ratio which serves the purposes of hedging milk production and a partial hedge of feed costs. It is shown that selling R1 is different from taking a short position in milk futures and a long position in corn futures at the same time later in this chapter. The second futures contract R2 is based on milk-feed price ratio which provides dairy

[4] Daily trading volume of corn and soybean futures on the Chicago Board of Trade is much higher than the volume in milk contracts.

farms an additional tool for hedging the relationship between the revenue from selling milk and costs from feeding cows.

This chapter will first provide detailed information on the definition, specification and pricing model for the proposed ratio futures contracts. By plugging simulated data into the derived formulas of price behaviors of the two new futures contracts, it is proved that the two contracts could be created and priced. Then, a simple farm profit model is developed. Finally, the farm profits from dairy operation under six different scenarios are being considered: no hedging, short Class III milk futures, long corn futures, short Class III milk futures and long corn futures simultaneously, short milk-corn price ratio futures and short milk-feed price ratio futures. An optimal hedge ratio is derived under the latter five scenarios using price levels. All assumptions made are aiming at singling out the effects of other risk factors on the farm profit from dairy operation but the price risk faced by producers.

3.2 Futures contract R1 based on milk-corn price ratio

The concept of nearby futures contract is important when creating futures contracts based on mark to market ratios. When several futures contracts are considered, the contract with the closest settlement date is called the nearby futures contract[5]. It is a

[5] For example, USDA announced February 2010 class III milk price on March 5th, 2010. January 10 contract stopped trading on February 4th, 2010 while February 10 contract stopped trading on March 4th, 2010. Daily prices of February 10 class III milk contract from the next trading day after 02/04/2010 to 03/04/2010 are obtained as the nearby futures price for class III milk.

much closer representation of the spot prices which is important when making hedging decisions[6]. After obtaining the nearby futures price series for milk, corn and soybean, it is now possible to create a new futures contract R1 based on the futures price ratio of milk to corn, which is defined as,

$$R_1 = \frac{m}{c} \qquad (5)$$

where m and c are the referencing futures price of Class III milk and corn. By taking a short position in R1, dairy farmers are protecting themselves from potential decrease in the milk to corn price ratio.

The proposed futures contract R1 is a synthetic class III milk-corn price ratio futures contract. In order to proceed with building the hedging model later in the paper, some specifications of the contract is needed. Class III milk futures are delivered in every month of the year while corn futures are delivered only in March, May, July, September and December. For purpose of ease, R1 futures are assumed to be delivered in every calendar month. Most of the contract specifications are based on the specifications of the soybean-corn price ratio futures listed on CME.

Contract Size	Ratio of Class III Milk futures price divided by the Corn futures price.
Tick Size	0.001
Price Basis	Price ratio between one Class III Milk futures contract and one Corn futures contract, rounded to the nearest 1/1.000th of a point (0.001).

[6] Refer to the discussion of basis risk in Chapter 3.4.1 Mechanism of futures hedging and basis risk.

Contract Months	All Calendar Months
Settlement Procedure	Cash Settlement
Daily Price Limit	Limits on each individual leg[7].

3.3 Futures contract R2 based on milk-feed price ratio

Contract R1 would help dairy producer hedge against price risk of milk and part of the feed (corn). A more complicated contract R2 is developed with the objective of protecting profit margin, which is dairy income over feed costs. If both corn and soybean are considered as feed costs to hedge, the new futures contract R2 is then based on the nearby futures price ratio of milk to feed. R2 is defined as,

$$R_2 = \frac{m}{\alpha c + (1-\alpha)s} \qquad (6)$$

where m, c, s are the referencing futures price of Class III milk, corn and soybean. αc is the percentage of costs of corn to feed costs (costs of corn + costs of soybean) per unit of milk produced, $(1-\alpha)s$ is the percentage of costs of soybean to feed costs. Contract specifications of R2 are similar to those of R1 except for the contract size. The value of α will be discussed later in Chapter 4.

Contract Size	Ratio of Class III Milk futures price divided by a combination of the Corn futures price and the Soybean futures price ($\alpha c + (1-\alpha)s$).
Tick Size	0.001
Price Basis	Price ratio between one Class III Milk futures contract and one Corn futures contract, rounded to the nearest 1/1.000th of a point

[7] In this case, R1 should follow the limits on Class III Milk and Corn futures.

	(0.001).
Contract Months	All Calendar Months
Settlement Procedure	Cash Settlement
Daily Price Limit	Limits on each individual leg.

3.4 The stochastic process of R1 and R2

This section develops the stochastic process of R1 and R2 assuming the nearby futures price series of Class III milk, corn and soybean follow geometric Brownian motion. Using Ito's Lemma, it shows that the Ito's process generated from the milk to corn price ratio futures is different from the process generated from short milk futures and long corn futures simultaneously, even though both strategies are hedging against a decreasing milk price and increasing corn price. The derivation lays out a foundation for potential further research on pricing options on R1 and R2 futures using Black-Scholes model. However, the thesis does not provide a context of pricing the options nor is it applied with the actual farm data.

To model the price behaviors of R1 and R2, assume nearby futures prices of Class III milk futures, corn futures and soybean futures follow geometric Brownian motion.

$$\frac{dm_t}{m_t} = \mu_m dt + \sigma_m dz_m \tag{7}$$

$$\frac{dc_t}{c_t} = \mu_c dt + \sigma_c dz_c \tag{8}$$

$$\frac{ds_t}{s_t} = \mu_s dt + \sigma_s dz_s \tag{9}$$

where m, c, s represents milk, corn and soybean respectively;

$\frac{dm_t}{m_t}$ = percentage change in milk futures price during time dt;

μ_m= expected growth rate in Class III milk futures price (drift term);

σ_m= variance of percentage return;

z_m is a Wiener process;

Apply Ito's Lemma, the process followed by $R_1 = \frac{m}{c}$ is derived as,

$$\frac{dR_{1,t}}{R_{1,t}} = (\mu_m - \mu_c - \sigma_m\sigma_c\rho_{mc})dt + \sigma_m dz_m - \sigma_c dz_c \qquad (10)$$

where ρ_{mc} is the coefficient of correlation between the two processes of milk and corn futures prices. Detailed derivation is shown in Appendix 1.

Hence, over any finite time interval T, the percentage change in R_1 is normally distributed with mean $(\mu_m - \mu_c - \sigma_m\sigma_c\rho_{mc})T$ and variance $(\sigma_m^2 + \sigma_c^2 - 2\sigma_m\sigma_c\rho_{mc})T$. R_1 follows Ito's process.

$$\widetilde{R_{1,t}} = \widetilde{R_{1,t-1}}\, exp((\mu_m - \mu_c - \sigma_m\sigma_c\rho_{mc})\, dt + N(0,1)\sigma_m\sqrt{dt} - N(0,1)\sigma_c\sqrt{dt}) \qquad (11)$$

It is worth noticing that by taking a short position in milk futures and a long position in corn futures, dairy farmers are also protecting themselves from decreasing milk prices and increasing feed costs. It could be represented by creating a synthetic futures contract $\bar{R}$, where $\bar{R} = \alpha m - \beta c$. The Ito's processes generated from $\bar{R}$ are different from R_1.

$$d\overline{R_t} = (\alpha\mu_m m_t - \beta\mu_c c_t)dt + \alpha\sigma_m m_t dz_m - \beta\sigma_c c_t dz_c \qquad (12)$$

Compared to taking a short position in milk futures and a long position in corn futures at the same time, R1 reduces transaction costs as farmers only need to adjust the position of R1 should the prices of milk or corn change.

The pricing model of this futures contract is derived by applying Ito's lemma to the processes of milk and corn. This generates the Ito's process followed by R_1, named as $\widetilde{R_1}$. A monte-carlo simulation approach is used to examine the feasibility of this new futures contract. Under one single simulation, I will generate two price series of R_1 with different underlying Ito's processes. One series is generated directly from the newly derived process $\widetilde{R_1}$; another is generated from taking the ratio of the price series of milk to corn, namely $(\frac{m_t}{c_t})$, which are simulated from their respective processes. Note that the random shocks to Class III milk, corn and soybean futures prices are correlated. If the two simulated processes are always identical under each simulation, assuming the time interval is very small, it is then feasible to create this new futures contract. Detailed procedures are described in Appendix 3.

Similar to the derivation for R_1 based on milk-corn price ratio, apply Ito's lemma, the Ito's process followed by R_2 is written as,

$$
\begin{aligned}
\widetilde{R_{2,t}} = \widetilde{R_{2,t-1}}\, exp\Bigg(& (\mu_m - \frac{\alpha c_t}{\alpha c_t + (1-\alpha)s_t}(\mu_c \\
& + \sigma_m \sigma_c \rho_{mc}) - \frac{(1-\alpha)s_t}{\alpha c_t + (1-\alpha)s_t}(\mu_s + \sigma_m \sigma_s \rho_{ms}) \\
& + \frac{2\alpha(1-\alpha)c_t s_t}{(\alpha c_t + (1-\alpha)s_t)^2}\sigma_c \sigma_s \rho_{cs})dt \\
& + N(0,1)\sigma_m \sqrt{dt} \\
& - N(0,1)\frac{\alpha c_t}{\alpha c_t + (1-\alpha)s_t}\sigma_c \sqrt{dt} \\
& - \frac{(1-\alpha)s_t}{\alpha c_t + (1-\alpha)s_t}\sigma_s \sqrt{dt}\Bigg)
\end{aligned} \tag{13}
$$

Where,

$$
c_t = c_{t-1}\, exp\left((\mu_c - \frac{1}{2}\sigma_c^2)dt + N(0,1)\sigma_c \sqrt{dt}\right)
$$

$$
s_t = s_{t-1}\, exp\left((\mu_s - \frac{1}{2}\sigma_s^2)dt + N(0,1)\sigma_s \sqrt{dt}\right)
$$

Appendix 2 presents the detailed derivation of the stochastic process followed by R2.

3.5 Derivation of hedge ratio

3.5.1 Mechanism of futures hedging and basis risk

Futures provide dairy producers the instruments to reduce market price risk through hedging without interfering with their normal marketing and pricing process of the products. In general, the changes of nearby futures prices and changes of spot prices are highly correlated. Dealers price the local cash grain prices as the nearby futures prices minus a local basis. Hence, local cash and nearby futures prices change by similar amounts.

Short hedges protect selling prices while long hedges protect purchase prices. A short hedge using Class III milk futures allows milk producers to forward price the butterfat, protein and other nonfat milk solids in multiple component pricing. If the producer loses money because of a decline in the milk cash market, he or she could gain the loss back in the futures market. On the other hand, dairy farmers can lock in part of the feed costs through a long hedge using corn or soybean futures. If the hedging is a perfect hedge, gains (losses) in the cash market should be exactly offset by losses (gains) in the futures market. However, cash and futures prices for the same commodity do not always move together. Thus, the existence of basis risk brings more considerations to the effectiveness of futures as price risk management tools.

The 'basis' is defined as the difference between the local spot price and the futures price[8].

$$B(t) = P(t) - F(t, T) \tag{14}$$

where T is the contract maturity. It implies that basis can change from day to day. In no-arbitrage world, the convergence of spot price and futures price is assured as the delivery date for the futures contract approach.

For cash-settled futures contracts as Class III milk futures, the nearby futures contracts terminate trading immediately preceding the day on which the USDA announces the

[8] The academic approach used to define "basis" as the difference between futures price and local spot price.

Class III milk price for that contract month[9] and are settled against the actual cash price announced[10].

As pointed out by John Hull, increasing levels of uncertainty over basis risk should be aware of if (1) the hedge requires that the futures contract be closed out well before its expiration date (2) the commodity whose price is to be hedged may not be exactly the same as the underlying commodity of the futures contract. The basis risk faced by dairy producers for milk relates to the difference between their mailbox price and the Class III futures price. The perfect convergence of Class III milk cash and futures prices guarantees no basis risk for that part of the producer's mailbox price. The rest part of the producer's mailbox price is exposed to basis risk since producers can influence the quality and component content of the milk. In "Futures and Options Trading in Milk and Dairy Products" written by Jesse and Cropp, they explained that the component prices for butterfat, protein and other solids link the Class III milk futures price and a producer's specific mailbox price: the component prices are the same while a producer's milk composition might be different from the standard composition (3.5 pounds of butterfat, 2.99 pounds of protein and 5.69 pounds of other solids for per 100 pounds of milk) used to derive the Class III price. The basis will be

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[9] Monthly prices used to settle the Class III milk futures are usually released on the Friday before the 5th of the following month by NASS. If the 5th falls on Friday, data is then released on that Friday.

[10] Class III milk futures have been trading at CME since 1996 in various forms as cash-settled futures contract. CME has refined its futures contract over time to keep up with the ever-changing government price support program for milk. Cash settlement was originally based on the Minnesota-Wisconsin price, then the Basic Formula Price (BFP) and currently the Class III milk price.

affected by the difference. A schematic illustrating the relationship between the Class III price and the mailbox price by Jesse and Cropp is presented in Appendix.

In the case of hedging with corn and soybean futures, the feed costs are only approximately hedged because (1) corn and soybean are only part of the total dairy feed costs; (2) most milk producers feed soybean meal, not just soybeans (some use roasted soybeans); (3) farmers are buying corn and soybean in New York State while the futures contracts on CME are for delivery in Illinois; (4) the futures prices are for Yellow 2 corn and Yellow 2 soybean[11] respectively while dairy feed may not be the same grade and thus may result in increasing basis. It appears to be very difficult for the hedging to be a perfect hedge using instruments that are currently available in the market.

Thus, basis risk always exists unless there is a perfect correlation between the local cash price and futures price. Since basis risk represents the difference of two correlated price series, it is usually significantly less than the price risk that farmers face. It would be an effective hedge if the basis risk is low enough to cover the hedging costs so that the farmers are exposed to basis risk while the exposure to price risk is reduced.

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[11] As defined by CME regarding the deliverable grade for Corn futures and Soybean futures, Yellow 2 Corn at contract price, Yellow 1 corn at a 1.5 cent/bushel premium, Yellow 3 corn at a 1.5 cent/bushel discount; Yellow 2 soybean at contract price, Yellow 1 soybean at a 6 cent/bushel premium, Yellow 3 soybean at a 6 cent/bushel discount.

Basis risk is possible to be reduced by tracking the historical basis for individual dairy producer. Take hedging with class III milk futures as an example. Since class III milk futures are settled in cash at announced milk prices, dairy producer can obtain the basis by subtracting the futures price from the producer mailbox price. Then, the producer could average the basis for each month over the past few years to get the forecast of a monthly basis. When making hedging decisions, dairy producer can add the estimated basis to the class III milk futures price to determine the cash price at the time milk is sold.

The proposed futures contracts R1 and R2 are designed as cash settlement upon maturity. The market level basis risk is zero if hedging with these contracts. The individual farmer still has basis risk since the mailbox price of milk is different from the average state milk price received; the feed costs paid are not the average state feed costs and the feed costs in the model only represent part of the total feed costs.

3.5.2 Farm profit model and sources of risk

Net farm income is a common practice to measure the financial year result of dairy farm's whole operations. In United States agricultural policy, net farm income refers to the return (both monetary and non-monetary) to farm operators for their labor, management and capital, after all production expenses have been paid[12]. Since our hedging focuses on price risk reduction, farm profit from dairy operations is derived

[12] Source: http://en.wikipedia.org/wiki/Net_farm_income

rather than using net farm income. The farm profit from dairy operations without hedging is defined as,

$$\pi = milk\ sales - feed\ costs - other\ operating\ costs \qquad (15)$$

The total feed costs have three components: costs of corn, costs of soybean and costs of alfalfa hay. Feed costs for farm i can be written as,

$$C_i = Q_{ci}P_{ci} + Q_{si}P_{si} + Q_{hi}P_{hi} \qquad (16)$$

where P_{ci} = purchase price of corn;

P_{si} = purchase price of soybean;

P_{hi} = purchase price of alfalfa hay;

Assume all dairy producers feed cows based on a standard dairy ration with fixed quantity of corn, soybean and alfalfa hay, then assume $Q_c = aQ_m$, $Q_s = bQ_m$, $Q_h = cQ_m$ for all dairy farms, where Q_m is the quantity of milk produced and sold during a time period of T, Q_c, Q_s and Q_h are the quantity of corn, soybean and alfalfa hay purchased during the corresponding time period. Also assume the feed purchased are consumed entirely during this time period with no inventory.

Substitute $Q_c = aQ_m$, $Q_s = bQ_m$, $Q_h = cQ_m$ into (16),

$$C_i = aQ_{mi}P_{ci} + bQ_{mi}P_{si} + cQ_{mi}P_{hi} \qquad (17)$$

Suppose other operating costs K is a fixed proportion of the quantity of milk sold, $K = kQ_m$, k is a constant. The farm profit from dairy operations can be written as,

$$\pi_i = Q_{mi}P_{mi} - (Q_{ci}P_{ci} + Q_{si}P_{si} + Q_{hi}P_{hi}) - K_i \qquad (18)$$

Thus,

$$\pi_i = Q_{mi}P_{mi} - Q_{mi}(aP_{ci} + bP_{si} + cP_{hi} + k_i) \qquad (19)$$

In other words, the equation for farm profits could be established as,

$$Farm\ profit\ (\$/cwt) = milk\ volume\ (cwt) \times (milk\ price (\$/cwt) - feed\ costs (\$/cwt) - other\ operating\ costs\ (\$/cwt)) \quad (20)$$

The variance of farm profit model described above is given by:

$$\sigma_{\pi_i}^2 = \sigma_{Q_{mi}}^2 (\sigma_{P_{mi}}^2 + a^2\sigma_{P_{ci}}^2 + b^2\sigma_{P_{si}}^2 + c^2\sigma_{P_{hi}}^2 + k^2 - 2acov(P_{mi}, P_{ci}) - 2bcov(P_{mi}, P_{si}) - 2ccov(P_{mi}, P_{hi}) + 2abcov(P_{ci}, P_{si}) + 2bccov(P_{si}, P_{hi}) + 2accov(P_{ci}, P_{hi}) - 2cov(P_{mi}, k_i) + 2acov(P_{ci}, k_i) + 2bcov(P_{si}, k_i) + 2ccov(P_{hi}, k_i)) \quad (21)$$

The derivation indicates that the sources of risk for individual dairy farm profit include production risk, price risk and risk from operating costs. Production risk comes from the uncertainty of the quantity of milk produced and sold which could be different from the expectation of the dairy producer. However, the production risk for dairy producers is relatively small compare to other agricultural products producers as it is not significantly influenced by unpredictable factors, such as weather. Price risk comes from the volatility of milk price and prices for each of the feed component. It could be fairly significant as the prices of agricultural commodities tend to be volatile and difficult to be forecasted accurately. Operating costs, which mainly characterize labor and machinery costs, could vary from time to time based on the economic condition and farm operating efficiencies.

The market hedging instruments discussed in this thesis, namely futures contracts, could only be used to hedge against the price risk faced by dairy producers, leaving the other sources of risk unhedged. In addition, futures contract may not perfectly hedge against all the price risks because of the existence of basis risk. Therefore, it is reasonable to assume the quantity of milk produced and operating costs are independent from the hedging decision. Production risk is ignored in the derivation of optimal hedge ratio. Risk from operating costs is isolated by assuming operating costs are proportional to the quantity of milk produced and the ratio remains the same across years for the same farm. These assumptions serve to better reflect the objective of hedging price risk with futures contract.

3.5.3 Optimal hedge ratio

The objective of this paper is to compare the effectiveness of hedging using R1 or R2 futures with the conventional hedging using milk, corn or soybean futures. Consider a dairy farm that expects the quantity of milk production over the next period to be $Q_{m,t-1}$ at time $t-1$ and takes out futures positions in a futures contract at the same time. $P_{m,t}$ is the spot price of milk in period t. $F_{m,t}$ is the futures price in period t for delivery at some future date. The futures positions are liquidated at time t. The dairy farm profit in period t with hedging position in one futures contract can be denoted as,

$$\pi_t = Q_{m,t-1}P_{m,t} - C - (F_{m,t} - F_{m,t-1})h_{t-1}Q_{m,t-1} \qquad (22)$$

where h_{t-1} is the hedge ratio to the quantity of milk production $Q_{m,t-1}$. If $h > 0$, it implies a short position. If $h < 0$, it implies a long position. C is a cost function of feed costs and operating costs.

The objective is to maximize a linear function of the mean and variance of the farm profit in the next period by choosing the hedge ratio at the beginning of this period, conditional on available information,

$$\max_{h_{t-1}} E(\pi_t|X_{t-1}) - \frac{\lambda}{2} var(\pi_t|X_{t-1}) \qquad (23)$$

where X_{t-1} is a set of information available at time $t-1$, λ is a measure of the dairy farm's risk aversion. According to Myers and Thompson, if

(1) C is an increasing and convex cost function;

(2) Quantity of milk production is independent from hedging decision;

(3) Futures market is unbiased, $E(F_t|X_{t-1}) = F_{t-1}$;

then the optimal hedge ratio equals to,

$$h = \frac{\sigma_{P_m F_m}}{\sigma_{F_m}^2} \qquad (24)$$

If the futures market is biased, the derived hedge ratio satisfies the minimum variance of the profit function but is not mean-variance efficient (Heifer).

Six scenarios of the dairy farm profit are being compared in this paper. Five scenarios use futures contracts as hedging instrument. The six scenarios are:

(1) Hedge milk sales only: short class III milk futures

(2) Hedge costs of corn only: long corn futures

(3) Hedge milk sales and costs of corn simultaneously: short class III milk futures and long corn futures

(4) Hedge milk sales and costs of corn simultaneously: short futures contract R1

(5) Hedge milk sales and feed costs simultaneously: short futures contract R2

(6) No hedging

In the farm profit model of this paper, the cost function does not follow the properties as an increasing and convex function. As a result, the covariance between the variable in the cost function and the milk spot and futures price will influence the hedge ratio. The derivation of the optimal hedge ratio should be conducted for each hedging strategy rather than applying the simple hedge ratio.

(1) Hedge milk sales only: short class III milk futures

The profit function for dairy farm i is,

$$\pi_i^{h1} = Q_{mi}P_{mi} - Q_{mi}(aP_{ci} + bP_{si} + cP_{hi} + k_i) - (F_{m,t} - F_{m,t-1})h_1 Q_{mi} \tag{25}$$

Derive the variance of π_i^{h1} as,

$$\begin{aligned}\sigma^2_{\pi_i^{h1}} = {} & Q_{mi}^2\sigma^2_{P_{mi}} + a^2Q_{mi}^2\sigma^2_{P_{ci}} + b^2Q_{mi}^2\sigma^2_{P_{si}} + c^2Q_{mi}^2\sigma^2_{P_{hi}} \\ & + h_1^2Q_{mi}^2\sigma^2_{F_m} - 2aQ_{mi}^2cov(P_{mi}, P_{ci}) \\ & - 2bQ_{mi}^2cov(P_{mi}, P_{si}) - 2cQ_{mi}^2cov(P_{mi}, P_{hi}) \\ & + 2abQ_{mi}^2cov(P_{ci}, P_{si}) + 2bcQ_{mi}^2cov(P_{si}, P_{hi}) \\ & + 2acQ_{mi}^2cov(P_{ci}, P_{hi}) - 2h_1Q_{mi}^2cov(P_{mi}, F_{m,t}) \\ & + 2h_1aQ_{mi}^2cov(P_{ci}, F_{m,t}) + 2h_1bQ_{mi}^2cov(P_{si}, F_{m,t}) \\ & + 2h_1cQ_{mi}^2cov(P_{hi}, F_{m,t})\end{aligned} \tag{26}$$

Note that Q_{mi} and k_i are independent from the hedging, so both are removed from the hedge ratio calculations.

Obtain the optimal h_1 by minimizing the variance of π_i^{h1}. Take the first derivative of $\sigma^2_{\pi_i^{h1}}$ with respect to h_1 and set the equation equal to zero.

$$\frac{\partial \sigma^2_{\pi_i^{h1}}}{\partial h_1} = 2h_1 Q_{mi}^2 \sigma_{F_m}^2 - 2Q_{mi}^2 cov(P_{mi}, F_{m,t}) + 2aQ_{mi}^2 cov(P_{ci}, F_{m,t}) + 2bQ_{mi}^2 cov(P_{si}, F_{m,t}) + 2cQ_{mi}^2 cov(P_{hi}, F_{m,t}) = 0 \tag{27}$$

Thus,

$$h_1 = \frac{1}{\sigma_{F_m}^2}[cov(P_{mi}, F_{m,t}) - acov(P_{ci}, F_{m,t}) - bcov(P_{si}, F_{m,t}) - ccov(P_{hi}, F_{m,t})] \tag{28}$$

Since the objective is to hedge milk sales by taking a short position in class III milk futures, it would be more reasonable to assume milk, corn, soybean and alfalfa hay price series are independent from each other when calculating the hedge ratio, i.e. the covariance between cash price of corn and futures price of milk is equal to zero. However, simultaneously estimated, time-varying hedge ratios may achieve more hedging effectiveness for the soybean processing margin which had been examined in previous literature. Then, it would be important to consider the correlations among the cash and futures price of all the commodities involved. As summarized by Tomek and Peterson from an intensive literature review, time-varying covariance estimation is costly and often does not result in greater hedging effectiveness relative to unconditional hedge ratios. For the purpose of this paper, the farm profit model is set up to be hedging with only one futures instrument and the hedge ratio is not estimated as time-varying hedge ratios. The interaction between the cash and futures price of different commodities are not considered. The optimal hedge ratio for dairy farm i is,

$$h_1 = \frac{cov\left(P_{mi}, F_{m,t}\right)}{\sigma^2_{F_m}} \tag{29}$$

(2) Hedge costs of corn only: long corn futures

The profit function for dairy farm i is,

$$\begin{aligned} \pi_i^{h2} = Q_{mi}P_{mi} - Q_{mi}(aP_{ci} + bP_{si} + cP_{hi} + k_i) \\ - \left(F_{c,t} - F_{c,t-1}\right)h_2 Q_{mi} \end{aligned} \tag{30}$$

Derive the variance of π_i^{h1} as,

$$\begin{aligned} \sigma^2_{\pi_i^{h2}} = {} & Q^2_{mi}\sigma^2_{P_{mi}} + a^2Q^2_{mi}\sigma^2_{P_{ci}} + b^2Q^2_{mi}\sigma^2_{P_{si}} + c^2Q^2_{mi}\sigma^2_{P_{hi}} + h_2^2Q^2_{mi}\sigma^2_{F_c} \\ & - 2aQ^2_{mi}cov(P_{mi}, P_{ci}) - 2bQ^2_{mi}cov(P_{mi}, P_{si}) \\ & - 2cQ^2_{mi}cov(P_{mi}, P_{hi}) + 2abQ^2_{mi}cov(P_{ci}, P_{si}) \\ & + 2bcQ^2_{mi}cov(P_{si}, P_{hi}) + 2acQ^2_{mi}cov(P_{ci}, P_{hi}) \\ & - 2h_2Q^2_{mi}cov\left(P_{mi}, F_{c,t}\right) + 2h_2aQ^2_{mi}cov\left(P_{ci}, F_{c,t}\right) \\ & + 2h_2bQ^2_{mi}cov\left(P_{si}, F_{c,t}\right) + 2h_2cQ^2_{mi}cov\left(P_{hi}, F_{c,t}\right) \end{aligned} \tag{31}$$

Take the first derivative of $\sigma^2_{\pi_i^{h2}}$ with respect to h_2 and set the equation equal to zero.

$$\begin{aligned} \frac{\partial \sigma^2_{\pi_i^{h2}}}{\partial h_2} = {} & 2h_2Q^2_{mi}\sigma^2_{F_c} - 2Q^2_{mi}cov\left(P_{mi}, F_{c,t}\right) \\ & + 2aQ^2_{mi}cov\left(P_{ci}, F_{c,t}\right) + 2bQ^2_{mi}cov\left(P_{si}, F_{c,t}\right) \\ & + 2cQ^2_{mi}cov\left(P_{hi}, F_{c,t}\right) = 0 \end{aligned} \tag{32}$$

Thus,

$$\begin{aligned} h_2 = \frac{1}{\sigma^2_{F_c}} [& cov\left(P_{mi}, F_{c,t}\right) - acov\left(P_{ci}, F_{c,t}\right) \\ & - bcov\left(P_{si}, F_{c,t}\right) - ccov\left(P_{hi}, F_{c,t}\right)] \end{aligned} \tag{33}$$

Based on the assumptions above, the futures price of corn is uncorrelated with the cash price of milk, soybean and alfalfa hay. If the dairy producer only hedges the costs of corn, the optimal hedge ratio for dairy farm i is,

$$h_2 = \frac{-acov\left(P_{ci}, F_{c,t}\right)}{\sigma^2_{F_c}} \tag{34}$$

(3) Hedge milk sales and costs of corn simultaneously: short class III milk futures and long corn futures

The profit function for dairy farm i is,

$$\pi_i^{hm,hc} = Q_{mi}P_{mi} - Q_{mi}(aP_{ci} + bP_{si} + cP_{hi} + k_i) - (F_{m,t} - F_{m,t-1})h_m Q_{mi} - \left(F_{c,t} - F_{c,t-1}\right)h_c Q_{mi} \qquad (35)$$

where h_m and h_c are the hedge ratio for class III milk futures and corn futures respectively.

The variance of $\pi_i^{hm,hc}$ is derived as,

$$\begin{aligned}\sigma^2_{\pi_i^{hm,hc}} = {} & Q_{mi}^2\sigma_{P_{mi}}^2 + a^2Q_{mi}^2\sigma_{P_{ci}}^2 + b^2Q_{mi}^2\sigma_{P_{si}}^2 + c^2Q_{mi}^2\sigma_{P_{hi}}^2 + h_m^2Q_{mi}^2\sigma_{F_m}^2 \\ & + h_c^2Q_{mi}^2\sigma_{F_c}^2 - 2aQ_{mi}^2cov(P_{mi}, P_{ci}) - 2bQ_{mi}^2cov(P_{mi}, P_{si}) \\ & - 2cQ_{mi}^2cov(P_{mi}, P_{hi}) + 2abQ_{mi}^2cov(P_{ci}, P_{si}) \\ & + 2bcQ_{mi}^2cov(P_{si}, P_{hi}) + 2acQ_{mi}^2cov(P_{ci}, P_{hi}) \\ & - 2h_mQ_{mi}^2cov\left(P_{mi}, F_{m,t}\right) - 2h_cQ_{mi}^2cov\left(P_{mi}, F_{c,t}\right) \\ & + 2h_maQ_{mi}^2cov\left(P_{ci}, F_{m,t}\right) + 2h_mbQ_{mi}^2cov\left(P_{si}, F_{m,t}\right) \\ & + 2h_mcQ_{mi}^2cov\left(P_{hi}, F_{m,t}\right) + 2h_caQ_{mi}^2cov\left(P_{ci}, F_{c,t}\right) \\ & + 2h_cbQ_{mi}^2cov\left(P_{si}, F_{c,t}\right) + 2h_ccQ_{mi}^2cov\left(P_{hi}, F_{c,t}\right) \\ & + 2h_mh_cQ_{mi}^2cov(F_{m,t}, F_{c,t})\end{aligned} \qquad (36)$$

To solve for the optimal hedge ratios simultaneously, take the first derivative of the variance of π_i^{h1} with respect to h_m and h_c respectively and set both equations equal to zero.

$$\begin{aligned}\frac{\partial\sigma^2_{\pi_i^{hm,hc}}}{\partial h_m} = {} & 2h_mQ_{mi}^2\sigma_{F_m}^2 - 2Q_{mi}^2cov\left(P_{mi}, F_{m,t}\right) \\ & + 2aQ_{mi}^2cov\left(P_{ci}, F_{m,t}\right) + 2bQ_{mi}^2cov\left(P_{si}, F_{m,t}\right) \\ & + 2cQ_{mi}^2cov\left(P_{hi}, F_{m,t}\right) + 2h_cQ_{mi}^2cov(F_{m,t}, F_{c,t}) = 0\end{aligned} \qquad (37)$$

$$\begin{aligned}\frac{\partial\sigma^2_{\pi_i^{hm,hc}}}{\partial h_c} = {} & 2h_cQ_{mi}^2\sigma_{F_c}^2 - 2Q_{mi}^2cov\left(P_{mi}, F_{c,t}\right) + 2aQ_{mi}^2cov\left(P_{ci}, F_{c,t}\right) \\ & + 2bQ_{mi}^2cov\left(P_{si}, F_{c,t}\right) + 2cQ_{mi}^2cov\left(P_{hi}, F_{c,t}\right) \\ & + 2h_mQ_{mi}^2cov(F_{m,t}, F_{c,t}) = 0\end{aligned} \qquad (38)$$

Based on the assumptions above, the futures price of one commodity is uncorrelated with the cash price of another commodity in the model. We get two equations,

$$h_m\sigma_{F_m}^2 - cov\left(P_{mi}, F_{m,t}\right) + h_c cov(F_{m,t}, F_{c,t}) = 0 \tag{39}$$

$$h_c\sigma_{F_c}^2 + acov\left(P_{ci}, F_{c,t}\right) + h_m cov(F_{m,t}, F_{c,t}) = 0 \tag{40}$$

Solve the two equations and get,

$$h_m = \frac{cov(P_m, F_m)\sigma_{F_c}^2 + acov(P_c, F_c)cov(F_m, F_c)}{\sigma_{F_m}^2\sigma_{F_c}^2 - cov(F_m, F_c)^2} \tag{41}$$

$$h_c = \frac{cov(P_m, F_m)cov(F_m, F_c) + acov(P_c, F_c)\sigma_{F_m}^2}{cov(F_m, F_c)^2 - \sigma_{F_m}^2\sigma_{F_c}^2} \tag{42}$$

(4) Hedge milk sales and costs of corn simultaneously: short futures contract R1

The profit function for dairy farm i is,

$$\begin{aligned}\pi_i^{h3} = Q_{mi}P_{mi} - Q_{mi}(aP_{ci} + bP_{si} + cP_{hi} + k_i)\\ - (R_{1,t} - R_{1,t-1})h_3Q_{mi}\end{aligned} \tag{43}$$

Derive the variance of π_i^{h3}as,

$$\begin{aligned}\sigma_{\pi_i^{h3}}^2 = {} & Q_{mi}^2\sigma_{P_{mi}}^2 + a^2Q_{mi}^2\sigma_{P_{ci}}^2 + b^2Q_{mi}^2\sigma_{P_{si}}^2 + c^2Q_{mi}^2\sigma_{P_{hi}}^2\\ & + h_3^2Q_{mi}^2\sigma_{R_1}^2 - 2aQ_{mi}^2cov(P_{mi}, P_{ci})\\ & - 2bQ_{mi}^2cov(P_{mi}, P_{si}) - 2cQ_{mi}^2cov(P_{mi}, P_{hi})\\ & + 2abQ_{mi}^2cov(P_{ci}, P_{si}) + 2bcQ_{mi}^2cov(P_{si}, P_{hi})\\ & + 2acQ_{mi}^2cov(P_{ci}, P_{hi}) - 2h_3Q_{mi}^2cov\left(P_{mi}, R_{1,t}\right)\\ & + 2h_3aQ_{mi}^2cov\left(P_{ci}, R_{1,t}\right) + 2h_3bQ_{mi}^2cov\left(P_{si}, R_{1,t}\right)\\ & + 2h_3cQ_{mi}^2cov\left(P_{hi}, R_{1,t}\right)\end{aligned} \tag{44}$$

Take the first derivative of $\sigma_{\pi_i^{h3}}^2$ with respective to h_3 and set the equation equal to zero.

$$\begin{aligned}\frac{\partial\sigma_{\pi_i^{h3}}^2}{\partial h_3} = {} & 2h_3Q_{mi}^2\sigma_{R_1}^2 - 2Q_{mi}^2cov\left(P_{mi}, R_{1,t}\right)\\ & + 2aQ_{mi}^2cov\left(P_{ci}, R_{1,t}\right)\\ & + 2bQ_{mi}^2cov\left(P_{si}, R_{1,t}\right)\\ & + 2cQ_{mi}^2cov\left(P_{hi}, R_{1,t}\right) = 0\end{aligned} \tag{45}$$

Thus,

$$h_3 = \frac{1}{\sigma_{R_1}^2}\left[cov(P_{mi}, R_{1,t}) - acov(P_{ci}, R_{1,t}) \right. \\ \left. - bcov(P_{si}, R_{1,t}) - ccov(P_{hi}, R_{1,t})\right] \quad (46)$$

The definition of the price of R1 contract is the ratio of class III milk futures price divided by corn futures price. Cash and futures price are considered highly correlated for identical underlying commodity. The covariance between futures price of R1 contract and cash price of milk and corn should be considered as non-zero. Based on the assumptions above, the futures price of R_1 is uncorrelated with the cash price of soybean and alfalfa hay. If the dairy producer hedges the profit margin by taking a short position in futures contract R1, the optimal hedge ratio for dairy farm i is,

$$h_3 = \frac{cov(P_{mi}, R_{1,t}) - acov(P_{ci}, R_{1,t})}{\sigma_{R_1}^2} \quad (47)$$

(5) Hedge milk sales and feed costs simultaneously: short futures contract R2

The profit function for dairy farm i is,

$$\pi_i^{h4} = Q_{mi}P_{mi} - Q_{mi}(aP_{ci} + bP_{si} + cP_{hi} + k_i) \\ - (R_{2,t} - R_{2,t-1})h_4Q_{mi} \quad (48)$$

Derive the variance of π_i^{h4}as,

$$\begin{aligned}\sigma_{\pi_i^{h4}}^2 = {} & Q_{mi}^2\sigma_{P_{mi}}^2 + a^2Q_{mi}^2\sigma_{P_{ci}}^2 + b^2Q_{mi}^2\sigma_{P_{si}}^2 + c^2Q_{mi}^2\sigma_{P_{hi}}^2 \\ & + h_4^2Q_{mi}^2\sigma_{R_2}^2 - 2aQ_{mi}^2cov(P_{mi}, P_{ci}) \\ & - 2bQ_{mi}^2cov(P_{mi}, P_{si}) - 2cQ_{mi}^2cov(P_{mi}, P_{hi}) \\ & + 2abQ_{mi}^2cov(P_{ci}, P_{si}) + 2bcQ_{mi}^2cov(P_{si}, P_{hi}) \\ & + 2acQ_{mi}^2cov(P_{ci}, P_{hi}) - 2h_4Q_{mi}^2cov(P_{mi}, R_{2,t}) \\ & + 2h_4aQ_{mi}^2cov(P_{ci}, R_{2,t}) + 2h_4bQ_{mi}^2cov(P_{si}, R_{2,t}) \\ & + 2h_4cQ_{mi}^2cov(P_{hi}, R_{2,t})\end{aligned} \quad (49)$$

Take the first derivative of $\sigma_{\pi_i^{h4}}^2$ with respective to h_4 and set the equation equal to zero.

$$\frac{\partial \sigma^2_{\pi_i^{h4}}}{\partial h_4} = 2h_4 Q_{mi}^2 \sigma_{R_2}^2 - 2Q_{mi}^2 cov(P_{mi}, R_{2,t}) + 2aQ_{mi}^2 cov(P_{ci}, R_{2,t}) + 2bQ_{mi}^2 cov(P_{si}, R_{2,t}) + 2cQ_{mi}^2 cov(P_{hi}, R_{2,t}) = 0 \quad (50)$$

$$h_4 = \frac{1}{\sigma_{R_2}^2}[cov(P_{mi}, R_{2,t}) - acov(P_{ci}, R_{2,t}) - bcov(P_{si}, R_{2,t}) - ccov(P_{hi}, R_{2,t})] \quad (51)$$

The definition of the price of R2 contract is the ratio of class III milk futures price divided by a combination of corn futures price and soybean futures price. The price series of R2 contract is independent from alfalfa hay cash prices but correlated with milk, corn and soybean cash prices. If the dairy producer hedges the profit margin by taking a short position in futures contract R2, the optimal hedge ratio for dairy farm i is,

$$h_4 = \frac{cov(P_{mi}, R_{2,t}) - acov(P_{ci}, R_{2,t}) - bcov(P_{si}, R_{2,t})}{\sigma_{R_2}^2} \quad (52)$$

Chapter 4 DATA DESCRIPTION AND METHODS

4.1 Introduction

This chapter provides detailed description of the sources of data, the assumptions made when applying data into the established theoretical framework, the procedures of obtaining the results and the limitations of data and methods. The objective is to analyze the effectiveness of hedging with different hedging instruments.

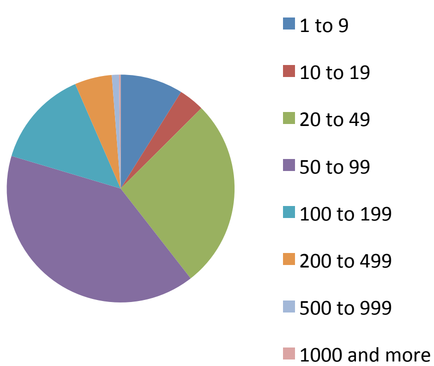
Mean-variance framework is applied to achieve this objective by comparing the individual farm profit over the past years under each of the six scenarios explained in chapter 3.

4.2 Sample data description

New York State dairy farm data is provided by Wayne Knoblauch and Linda Putnam at Cornell University. The data set includes 36 New York State dairy farms with their dairy operation data from 1996 to 2010. These farms have been consistently taken part in the annual dairy farm survey conducted by Cornell University Extension for the past 15 years. Since the individual farm data are only available on an annual basis, the model has to be adjusted to represent the profit/loss from hedging position on an annual basis.

The data set can be viewed as a sample which are generally large in herd size with high net farm income. Therefore, the population is not all New York State dairy producers, but a population of relatively large dairy farms. In other words, the sample is not representative of the population of New York State dairy farms, but it is representative of New York State large dairy farms if there is no sampling error and assuming all techniques correct.

The figures below show the distribution of New York dairy farms and sample dairy farms by herd size in 1997, 2002 and 2007. The sample dairy farms are large in size. Most dairy farms in the sample feature a herd size greater than 100 in 1997 while this number increased to 200 in 2002 and 2007. The number of farms with a herd size greater than 200 only accounted for 7%, 8% and 10% of the total farms in New York in 1997, 2002 and 2007 respectively.



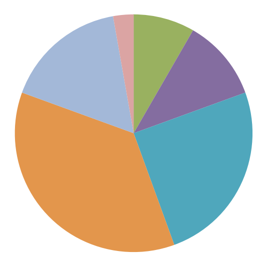
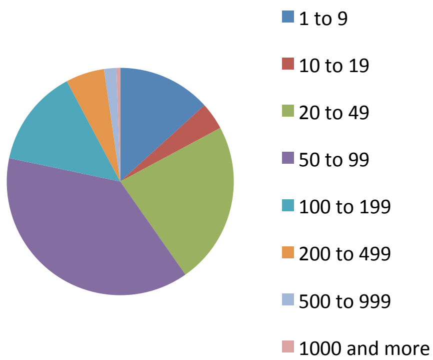


Figure 6 New York Dairy Farm Size 1997   **Figure 7 Sample Dairy Farm Size 1997**



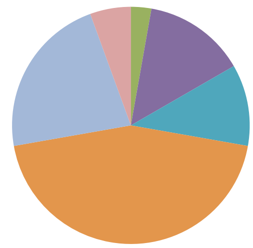
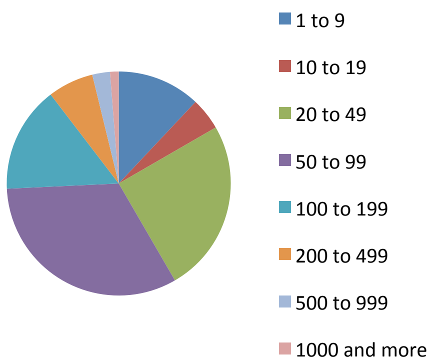


Figure 8 New York Dairy Farm Size 2002 **Figure 9 Sample Dairy Farm Size 2002**



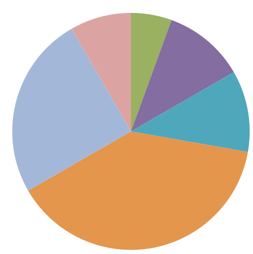


Figure 10 New York Dairy Farm Size 2007 **Figure 11 Sample Dairy Farm Size 2007**

In addition, sample farms tend to have higher net milk price received, higher operating efficiency and lower debt level compared to the average New York dairy farms. Take year 2007 as an example. The number of cows ranges from 45 to 1,620. As shown in Table 1, on average, sample dairy farms received a net milk price $1.74 higher than New York dairy farms in 2007; net farm income per cow without appreciation for sample dairy farms was 46% higher than New York dairy farms; sample dairy farms also had a higher debt coverage ratio indicating a lower financial risk.

Table 1. Comparison of New York Dairy Farms and Sample Dairy Farms, 2007

year 2007	**New York**	**Sample**
Average number of cows	170	454
net milk price ($/cwt.)	17.85	19.59
milk sold per worker (pounds)	832,054	888,512
dairy, feed & crop expense per cwt. Milk	7.39	6.17
net farm income per cow without appreciation ($)	856	1254
debt coverage ratio	2.27	3.90

From the above comparison, sample dairy farms used in this thesis are not representative of all New York State dairy farms. Thus, the implications summarized from the results may be biased and cannot be directly applied to the risk management strategies of dairy farms out of the sample.

4.3 Procedures and modifications

In order to meet the objective of the thesis, several assumptions have to be made so that the data would fit in the set-up of the model and other noises in the farm data would be eliminated.

Ideally, profit or loss from hedging should be measured on a more frequent basis, such as weekly or monthly. Our data restricts us from achieving monthly profit results of dairy farms. Since the objective of the thesis is to study the effectiveness of the proposed milk to feed ratio futures in reducing the variance of the dairy farm profit compared to conventional hedging instruments, the results should be of some indications as long as the comparison is equivalent in scale.

Farm profit model when hedging with milk futures is denoted as,

$$\pi_t = Q_{m,t-1}P_{m,t} - C - (F_{m,t} - F_{m,t-1})h_{t-1}Q_{m,t-1} \qquad (53)$$

The profit function is measuring the farm profit from dairy operations together with the profit or loss from hedging in futures market over the calendar year t. Assume dairy producers enter into the nearby futures contract at time $t-1$, which is the beginning of year t. Since the contract is on monthly basis, dairy producers are expected to settle the contract when it expires at time t_1 ($t-1 < t_1 < t$), and take position in the nearby futures contract at the same time. Then settle the contract at expiration of time t_2 ($t_1 < t_2 < t$) and simultaneously enter into the nearby futures contract. So on and so forth until the end of year t. Since the price series of nearby futures contract is considered as a continuous series from day to day, the profit or loss from this hedging position over year t could be approximated as the differences between the nearby futures price at the end of the year and the nearby futures price at the beginning of the year.

To meet the objective of comparing the historical effectiveness of hedging with different strategies under mean-variance framework, the procedures and modifications made are described in detail as follows.

(1) Represent the value of $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{c}$ and $\boldsymbol{\alpha}$ by the fixed standard dairy ration

Recall in Chapter 3, the farm profit model assumes $Q_c = aQ_m$, $Q_s = bQ_m$, $Q_h = cQ_m$ for all dairy farms when modeling the total feed costs for cows. These are based on the assumptions that,

a. Only feed costs consumed by lactating cows are considered[13];

b. All dairy producers feed cows based on a standard dairy ration with fixed quantity of corn, soybean and alfalfa hay;

c. Feed efficiencies are the same among all milk producers so that the volume of each component of the feed for producing hundredweight of milk are identical across farms;

d. All the feed are obtained through purchase[14], thus the purchased feed is the total feed costs.

All dairy producers in our sample are assumed to have the same feed costs structure. The feed costs are computed on per hundredweight of milk basis in this thesis. The data set reports an item listed as "Dairy Feed & Crop Expense per cwt. Milk"[15]. Some dairy producers only purchase part of the feed and grow the rest themselves, such as crops and grains. The costs of producing crops on a dairy farm could be a significant part of the cost of producing milk. This item contains not only the purchased feed costs for cows but also the crop expenses such as fertilizer & lime, seeds & plants, etc. Using it directly as feed costs would add noise to the model and may lead to biased results. Farm profit model in this paper assumes all feed costs are purchased, which is

[13] Generally, 65% of the feed costs for a dairy herd that raises its own replacements will be for the lactating cows, 30% for the heifers, and 5% for the dry cows. Source from "15 Measures of Dairy Farm Competitiveness", Ohio State University Extension.

[14] Dairy feed costs usually include both purchased feed costs and homegrown feed costs.

[15] The New York Farm Business Summary uses cost of cash crop inputs to represent homegrown feed costs.

a combination of costs of corn, soybean and alfalfa hay and assume all the other expenses as operating costs, which is proportionate to the quantity of milk produced. Instead of using the reported "Dairy Feed & Crop Expense per cwt. Milk", the feed costs are calculated from two steps.

a. Estimate the quantity of corn, soybean and alfalfa hay respectively in a hundredweight of dairy feed. A feed ration from USDA is adopted for this estimation;
b. Estimate the quantity of this standard diary feed needed if to produce a hundredweight of milk. This is achieved by making assumptions on feed efficiency and percentage of dry matter in the standard dairy feed.

The feed costs of producing hundredweight of milk are usually obtained from the top-down approach. That is, divide the total production of milk from the total feed costs. The feed costs structure in this work is established from bottom-up approach. The quantity of corn, soybean and alfalfa hay for producing per hundredweight of milk is approximated respectively by referencing a dairy feed ration. Multiply the quantity of each component by its unit price and sum up the three multiplications give the feed costs of producing hundredweight of milk.

For step a, the feed ration adopted in this paper is the ration that is used to compute the "milk-feed ratio" by USDA. The USDA's NASS division used Morrison's Feed and Feeding Manual and computed that 100 pounds of 16 percent protein dairy feed consists of 51 pounds of corn, 8 pounds of soybeans and 41 pounds of alfalfa hay. The USDA also calculated the feed cost per hundredweight in the "National Average Dairy Feed Costs". These cost figures can be replicated if one adopts the above feed ration[16]. The corn, soybean and alfalfa hay prices are monthly raw feed component prices reported by NASS. The formula used to compute the dairy feed costs per hundredweight is,

$$Feed\ cost\ percwt. = 51\times\frac{P_c(\$/bushel)}{56} + 8\times\frac{P_s(\$/bushel)}{60} + 41\times\frac{P_h(\$/ton)}{2000} \quad (54)$$

The unit for P_c, P_s and P_h in this formula is \$/bushel, \$/bushel and \$/ton respectively. In this thesis, all price units are converted to \$/cwt, then,

$$Feed\ cost\ percwt. = 0.51P_c + 0.08P_s + 0.41P_h \quad (55)$$

This is the "standard dairy feed" ration adopted for all dairy farms in our sample. Note that a dairy producer would not actually feed this mixed dairy feed but it is a representation of the energy (corn), protein (soybeans), and fiber (alfalfa) components of a standard dairy ration (Karlin). The drawback of this ration for the purpose of this work is that, prices for corn, soybean and hay could only be obtained at the national level rather than the state level.

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[16] Professor Brian W. Gould in the Department of Agricultural and Applied Economics at UW Madison maintains a website on "Understanding Dairy Markets". Data for "National Average Dairy Feed Costs" can be accessed at http://future.aae.wisc.edu/data/monthly_values/by_area/3002?tab=costs

For step b, several assumptions have to be made. First, feed efficiency has to be estimated for the average New York dairy farms. Feed efficiency can be defined as the quantity of milk produced per pound of dry matter (DM) consumed. It is such a complex matter that its value depends on many variables, such as body weight of cow, days in milk, forage quality etc. For simplicity, assume the average feed efficiency for New York dairy farms to be 1.6, which means that 1.6 pound of milk is produced per pound of dry matter intake (Hutjens)[17]. Next, the percentage of DM in a "standard dairy feed" is estimated. The percentage of DM in shelled corn, soybean meal and alfalfa hay is 89%, 90% and 85% respectively. For simplicity, assume the mixed dairy feed of corn, soybean and hay contains approximately 90% DM. Based on the two assumptions above, 1/0.9 pound of "standard dairy feed" is consumed to produce 1.6 pound of milk.

Therefore, to produce a hundredweight of milk, approximately 70 pounds of "standard dairy feed" is consumed on average. According to the feed ration that the quantity of corn: soybean: hay = 51: 8: 41, the 70 pounds of "standard dairy feed" consists of 35.6 pounds of corn, 5.6 pounds of soybean and 28.7 pounds of hay. Thus,

$$a = 0.357, b = 0.056, c = 0.287$$

The value of α is straightforward to obtain. By definition,

$$R_2 = \frac{m}{\alpha c + (1-\alpha)s} \tag{56}$$

[17] According to Hutjens, Feed efficiency reflects the level of fat-corrected milk yield produced per unit of dry matter consumed with an optimal range of 1.4 to 1.8 pounds of milk per pound of dry matter.

Recall that αc is the percentage of costs of corn to feed costs (costs of corn + costs of soybean) per unit of milk produced. $(1-\alpha)s$ is the percentage of costs of soybean to feed costs. Using the standard dairy feed ration in this work, we have

$$\frac{\alpha}{1-\alpha}=\frac{51}{8}$$

Thus $\alpha=\frac{51}{59}\approx 0.86$, $R_2=\frac{m}{0.86c+0.14s}$.

(2) Use historical average operating costs to calculate k for each farm

The item listed as "Labor and machinery costs per cow" in the dataset is considered as the operating costs in the farm profit model. Assume the quantity of milk produced equals the quantity of milk sold. For farm i, divide the labor and machinery costs per cow by the quantity of hundredweight of milk sold per cow for each year and then take a simple average. This would give us the value of k, which is the ratio of other operating costs to the quantity of cwt. of milk sold.

(3) Obtain nearby futures prices of Class III milk, corn and soybean and construct hypothetical daily nearby futures price series for R1 and R2

The daily nearby futures prices of class III milk, corn and soybean from 1996 to 2010 are obtained from Bloomberg. Convert the prices to the dollar value per hundred pounds.

Construct hypothetical daily nearby futures price series for R1 and R2 from 1996 to 2010 based on definition. For example, the price for R1 on 1/2/1996 equals to the ratio of Class III milk nearby futures price to the corn nearby futures price on that day.

Calculate the monthly and annual average nearby futures price for Class III milk, corn, soybean, R1 and R2 respectively. Results are shown in Appendix.

(4) Obtain cash prices of Class III milk , corn, soybean and alfalfa hay

The derived optimal hedge ratios in Chapter 3 contain the cash prices of Class III milk, corn, soybeans and alfalfa hay for the individual dairy producer. However, only net milk prices are reported annually on a farm basis. Feed prices are not reported in our dataset. Thus, we use the same cash prices for corn, soybeans and alfalfa hay for every dairy producer in our sample. The prices are the United States monthly average corn, soybeans and alfalfa hay price received by farmers from 1996 to 2010. Prices received by farmers are not available monthly for New York State in the USDA Feed Grains Database.

Even though the net milk prices are available for every farm, there are only 15 data points (from year 1996 to 2010) if used to calculate the covariance of cash milk price and futures milk price, which is very difficult to capture a representative correlation between the two price series. Thus, monthly New York all milk prices are used as an alternative when deciding the covariance and hedge ratios.

A hypothesis testing is conducted for each of the 36 sample dairy farms to see whether the NY all milk prices are significantly different from the net milk prices received by each farm. First, run a simple regression of NY all milk prices on the net milk prices received by farm i. Then, testing the null hypothesis H_0: $\beta_i = 1$ against the alternative

H_i: $\beta_1 \neq 1$. Compute $t = \frac{b-\beta}{\sqrt{\widehat{var}(b)}}$ and reject H_0 if $|t| > t_c$. The result shows that only 5 of the 36 null hypotheses are rejected. In other words, the net milk prices received by 31 dairy farms in the sample are not statistically different from the announced NY all milk prices[18].

Figure 6, 7 and 8 shows that the monthly nearby futures price and cash price for milk, corn and soybean used in the established model are highly correlated, which is the foundation of effective hedging if using these instruments. Prices are quoted as dollar per hundredweight. The mean of the basis between Class III milk nearby futures prices and New York all milk prices for the graphed period is 1.88 $/cwt. with a standard deviation of 1.29 $/cwt. The mean and standard deviation for the basis between corn nearby futures prices and U.S. average corn prices is -0.38 $/cwt. and 0.50 $/cwt. The mean and standard deviation for the basis between soybean nearby futures prices and U.S. average soybean prices is -0.53 $/cwt. and 0.78$/cwt. respectively.

[18] The result is under the significance level of 5%.

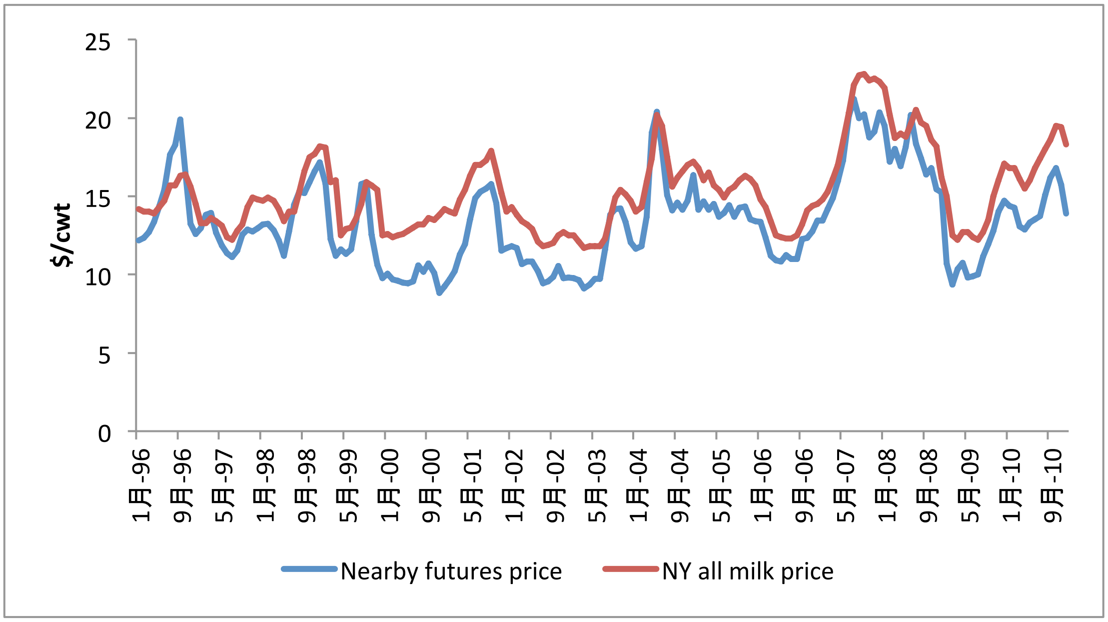

Figure 12 Monthly Class III Milk Nearby Futures Price and NY All Milk Price from 1996 to 2010

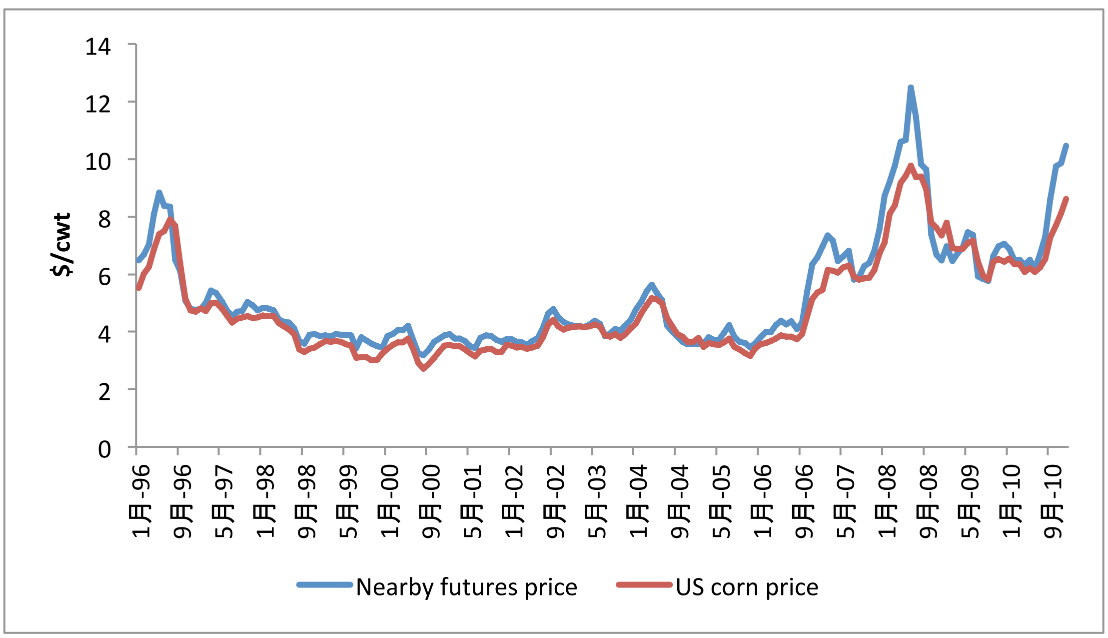

Figure 13 Monthly Corn Nearby Futures Price and US Average Corn Price Received from 1996 to 2010

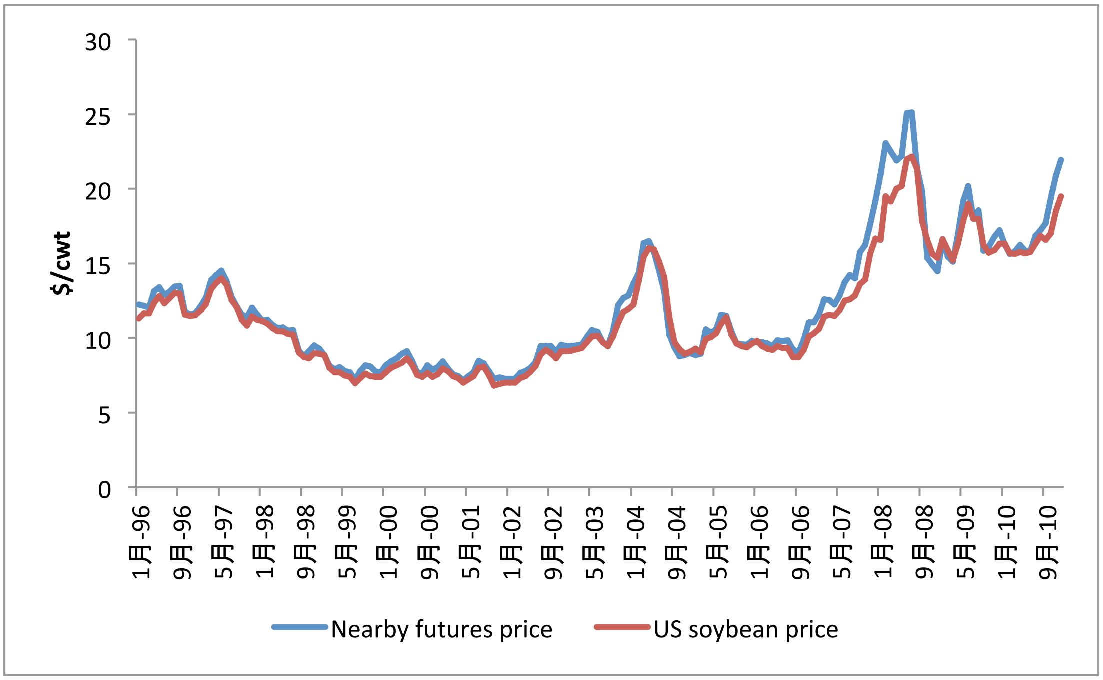

Figure 14 Monthly Soybean Nearby Futures Price and US Average Soybean Price Received from 1996 to 2010

(5) Calculate optimal hedge ratios

The following price series are used to calculate the optimal hedge ratios for five different hedging strategies:

a. P_m: monthly New York State all milk prices;

b. P_c, P_s, P_h: monthly average United States corn, soybeans and alfalfa hay prices received by farmers;

c. F_m, F_c, F_s, R_1, R_2: monthly average nearby futures prices of Class III milk, corn, soybeans, R1 and R2.

Assume the optimal hedge ratios are independent from dairy farm specification based on the modifications to the data. Therefore, for each hedging strategy, different farms will have the same optimal hedge ratio. The hedge ratios are also constant throughout the years based on the assumptions in the model. Calculations are described for each hedging strategy in the following paragraphs.

1. The optimal hedge ratio for short Class III milk futures is,

$$h_1 = \frac{cov(P_m, F_{m,t})}{\sigma_{F_m}^2}$$

Run a simple regression of monthly New York all milk prices on Class III milk nearby futures prices from 1996 to 2010. Coefficient β_1 is the estimate for h_1.

$$P_{m,t} = \beta_0 + \beta_1 F_{m,t} \qquad (57)$$

The point estimate for h_1 equals 0.803. It could be interpreted as for every unit of milk expected to be produced, it is optimal to take 0.803 unit of position in Class III milk futures to minimize the variance of return. It is statistically significant with a 95% confidence interval of (0.743, 0.863).

2. The optimal hedge ratio for long corn futures is,

$$h_2 = \frac{-acov(P_c, F_{c,t})}{\sigma_{F_c}^2}$$

Run a simple regression of monthly U.S. corn prices on corn nearby futures prices from 1996 to 2010. Coefficient β_1 is the estimate for $\frac{h_2}{-a}$.

$$P_{c,t} = \beta_0 + \beta_1 F_{c,t} \qquad (58)$$

The point estimate for $\frac{h_2}{-a}$ equals 0.850. It is statistically significant with a 95% confidence interval of (0.817, 0.882). The estimate for h_2 is 0.303. The 95% confidence interval for h_2 is (0.292, 0.315). To produce one unit of milk, 0.357 unit of corn input is expected. It is optimal to take 0.303 unit of position in corn futures for every unit of milk produced to minimize the variance of farm profit.

3. The optimal hedge ratios for short milk futures and long corn futures simultaneously are estimated using the price levels.

The price series of spot price of milk and corn, nearby futures price of milk and corn, allow us to obtain the variance covariance term in the equation for h_m and h_c. The point estimate for h_m and h_c is 1.170 and -1.161 respectively.

4. The optimal hedge ratio for short R1 futures is,

$$h_3 = \frac{cov(P_m, R_{1,t}) - acov(P_c, R_{1,t})}{\sigma_{R_1}^2}$$

Run two simple regressions. One is the regression of monthly New York all milk prices on R1 nearby futures prices from 1996 to 2010. The other is the regression of monthly U.S. corn prices on R1 nearby futures prices from 1996 to 2010.

$$P_{m,t} = \alpha_0 + \alpha_m R_{1,t} \quad (59)$$

$$P_{c,t} = \beta_0 + \beta_c R_{1,t} \quad (60)$$

α_m is the estimate for $\frac{cov(P_m, R_{1,t})}{\sigma_{R_1}^2}$. β_c is the estimate for $\frac{cov(P_c, R_{1,t})}{\sigma_{R_1}^2}$. Thus, $(\alpha_m - a\beta_c)$ is the estimate for h_3. The point estimate of α_m is 0.594, with a 95% confidence interval of (0.110, 1.078). The point estimate of β_c is -1.464, with a 95% confidence interval of (-1.693, -1.236). Therefore, the point estimate of h_3 is 1.117, with a 95% confidence interval of (0.551, 1.682).

5. The optimal hedge ratio for short R2 futures is,

$$h_4 = \frac{cov(P_m, R_{2,t}) - acov(P_c, R_{2,t}) - bcov(P_s, R_{2,t})}{\sigma_{R_2}^2}$$

Run three simple regressions. The first is the regression of monthly New York all milk prices on R2 nearby futures prices from 1996 to 2010. The second is the regression of monthly U.S. corn prices on R2 nearby futures prices from 1996 to 2010. The last is the regression of monthly U.S. soybean prices on R2 nearby futures prices from 1996 to 2010.

$$P_{m,t} = \alpha_0 + \alpha_m R_{2,t} \quad (61)$$

$$P_{c,t} = \beta_0 + \beta_c R_{2,t} \quad (62)$$

$$P_{s,t} = \gamma_0 + \gamma_s R_{2,t} \quad (63)$$

α_m is the estimate for $\frac{cov(P_m,R_{2,t})}{\sigma_{R_2}^2}$. β_c is the estimate for $\frac{cov(P_c,R_{2,t})}{\sigma_{R_2}^2}$. γ_s is the estimate for $\frac{cov(P_s,R_{2,t})}{\sigma_{R_2}^2}$. Thus, $(\alpha_m - a\beta_c - b\gamma_s)$ is the estimate for h_4. The point estimate of α_m is 0.685, with a 95% confidence interval of (0.096, 1.273). The point estimate of β_c is -1.785, with a 95% confidence interval of (-2.061, -1.509). The point estimate of γ_s is -3.694, with a 95% confidence interval of (-4.347, -3.042). Therefore, the point estimate of h_4 is 1.117, with a 95% confidence interval of (-0.272, 2.252).

The point estimates of hedge ratios are summarized in Table 2.

Table 2. Optimal Hedge Ratios

Hedging strategy	*Optimal hedge ratio*
short Class III milk	$h_1 = 0.803$
long corn	$h_2 = -0.303$
short Class III milk and long corn	$h_m = 1.170, h_c = -1.161$
short R1	$h_3 = 1.117$
short R2	$h_4 = 1.529$

(6) Calculate farm profit

The performance of these risk management strategies is presented by measuring net farm profit on both the scale of annual total farm profit and the scale of per hundredweight of milk. For farm i, the dairy farm milk sales over the year t equal the total milk produced multiplied by the net milk price received in that year. The feed costs over the year t equal feed costs per cwt. of milk discussed in (1) multiplied by the total milk produced. Operating costs equal the historical average ratio k_i multiplied by the total milk produced in year t. The profit or loss from hedging over year t in one futures contract is calculated as the differences between the nearby futures price at the end of the year and the nearby futures price at the beginning of the year. Use the annual average nearby futures price over year $t-1$ and year t to represent F_{t-1} and F_t respectively.

After obtaining the farm profit from year 1997 to year 2010[19] for all scenarios, calculate the mean and standard deviation of the farm profit under each of the six scenarios. Name it as "Case 1".

Then, remove the production risk factor from the Case 1 model by dropping the milk volume multiplier in the equation and get the net profit per hundredweight of milk for all scenarios. The fluctuation of production of milk over the years is excluded from the

[19] Since milk futures only started trading in 1996, the average nearby futures price in 1996 represents the nearby futures price at the beginning of 1997. Therefore, only farm profit from 1997 to 2010 could be obtained.

model. Name it as “Case 2”. For example, the net farm profit of milk for each year without hedging is calculated as,

$$\begin{aligned} &Net\ farm\ profit\ per\ cwt.of\ milk \\ &\qquad = milk\ price(\$/cwt) - feed\ costs(\$/cwt) \\ &\qquad - operating\ costs(\$/cwt) \end{aligned} \tag{64}$$

The model in this thesis assumes that operating costs is proportional to the quantity of milk produced and the ratio remains the same across years for the same farm, the risk factor embedded in operating costs has already been eliminated and does not affect the variance of the net farm profit.

At last, replicate the procedures for each farm in the dataset.

Chapter 5 RESULTS AND ANALYSIS

5.1 Results of one sample farm

Based on the procedures described in chapter 4, the following displays the result of a sample farm for Case 1, which measures the net farm profit for each year, and Case 2, which measures net farm profit per cwt. of milk for each year. Table 3 shows the Case 1 farm profit results of six scenarios for each year. To describe the results, for example, if this sample farm has undertaken no hedging strategies, the mean and standard deviation of net farm profit from 1997 to 2010 are $359,337 and $208,048 respectively.

We start with comparing short milk futures, short R1 futures and short R2 futures. All three strategies decrease the variance of net farm profit as expected while short milk futures reduce the expected return on average, short R1 or R2 futures increase the average net farm profit. If the dairy producer's utility is based on mean-variance efficiency, he or she would be better off if he or she had routinely taken a hedging position in R1 or R2 futures than no hedging. Short R2 futures is the most optimal strategy among these three as it results in the highest mean and lowest variance. Short milk and long corn simultaneously achieves a lower variance and higher mean compared to long corn strategy. Thus, short milk and long corn is a better strategy than long corn. Compare to no hedging, short R2 futures increase the mean by 2.6% and decrease the standard deviation of net farm profit by 5.5% while short milk and long corn simultaneously increase the mean by 4.9% and increase the standard deviation by 18.6%. These numbers are estimates for one farm in the sample period from 1997 to 2010. If the dairy producer's objective is to reduce the variance of net return and gain the upside potential, taking a short position in R2 is a preferable strategy. Even though short milk and long corn strategy provides more upside potential, the risk is significantly higher that may not justify the return for dairy producer for this sample farm. The quantitative methods that could be used to measure the relationship of risk and return are not the objective of this work. Rather, the thesis would like to look for indications from the results based on a qualitative approach and discussion.

It is worth noticing that either by taking a short position in R1 or short milk and long corn simultaneously, dairy producers are protecting their dairy income over costs of corn. The performances of hedging, however, are very different. Both strategies increase the average return while only short R1 futures decreases the variance of return at the same time.

Table 3. Net Farm Profit (dollar return per year)

year	***no hedge***	***short milk***	***long corn***	***short milk and long corn***	***short R1***	***short R2***
1997	107,592	173,059	80,336	123,620	96,444	103,087
1998	239,129	187,503	227,249	124,025	193,084	181,903
1999	310,934	380,477	299,472	381,663	314,563	305,229
2000	247,621	392,664	247,855	469,252	310,853	328,303
2001	368,145	195,264	367,776	103,703	291,736	268,144
2002	183,922	348,339	195,326	469,355	278,612	302,392
2003	180,756	123,336	184,081	103,508	166,511	179,780

2004	436,044	207,311	446,886	120,952	366,112	361,180
2005	469,772	551,059	442,428	509,625	435,792	430,789
2006	269,301	399,870	299,090	559,628	385,295	384,163
2007	719,906	310,881	792,859	320,913	707,540	705,281
2008	519,095	558,085	630,526	920,605	622,218	643,719
2009	179,552	793,876	31,847	661,722	213,447	235,693
2010	798,950	408,975	865,167	408,293	751,545	730,410
mean	359,337	359,336	365,064	376,919	366,697	368,577
std.	208,048	184,635	249,819	246,818	200,124	196,684

Table 3 presents the Case 2 results of the sample farm. Measurement is scaled to per hundredweight of milk. As shown in Table 3, the average net farm profit per cwt. of milk for the sample farm is $4.666 with a standard deviation of $1.923 if the producer takes no hedging position. The results are very similar to Case 2 for this sample farm. Short R1 or R2 futures both reduce more variance than the traditional hedging using milk or corn futures. Short R2 futures is the optimal strategy compare to no hedging, short milk, long corn and short R1 futures as it achieves the lowest standard deviation but the highest mean among these strategies. Compare to no hedging, short R2 futures increase the mean by 1.1% and decrease the standard deviation of net farm profit by 12.3% while short milk and long corn simultaneously increase the mean by 2.7% and increase the standard deviation by 35.8%. It seems that the short milk and long corn strategy is too risky that the reward for bearing the risk may not be big enough. However, without quantifying the risk-return relationship and the risk preference of the dairy producer, it is difficult to decide whether short R2 futures or short milk and long corn simultaneously would maximize the utility for this sample farm.

Table 4. Net Farm Profit per cwt. of Milk ($/cwt.)

year	no hedge	short milk	long corn	short milk and long corn	short R1	short R2
1997	3.148	5.064	2.351	3.617	2.822	3.016
1998	6.231	4.886	5.921	3.232	5.031	4.740
1999	5.558	6.801	5.353	6.823	5.623	5.456
2000	3.908	6.196	3.911	7.405	4.905	5.181
2001	5.540	2.938	5.534	1.560	4.390	4.035
2002	2.348	4.447	2.493	5.992	3.557	3.860
2003	2.514	1.715	2.560	1.439	2.316	2.500
2004	5.956	2.832	6.104	1.652	5.001	4.934
2005	5.822	6.830	5.484	6.316	5.401	5.339
2006	3.599	5.344	3.997	7.479	5.149	5.134
2007	8.633	3.728	9.508	3.848	8.484	8.457
2008	5.544	5.961	6.734	9.832	6.646	6.875
2009	1.444	6.383	0.256	5.320	1.716	1.895
2010	5.078	2.599	5.498	2.595	4.776	4.642
mean	4.666	4.695	4.693	4.794	4.701	4.719
std.	1.923	1.690	2.303	2.612	1.741	1.687

5.2 Results summary of all sample farms

Both the Case 1 and Case 2 results for the 36 New York dairy farms are identical across farms from a qualitative perspective. Since Case 2 model drops the production multiplier, production risks confronted by different dairy producers are isolated. Therefore, we should expect the effectiveness of hedging price risks using different strategies be more uniform across farms in Case 2. The results for each farm are presented in Appendix.

First, we analyze the hedging effectiveness of three strategies: short milk, long corn, short milk and long corn simultaneously. Traditional hedging with milk futures or corn futures or both does not necessarily reduce the variance of the farm profit compared to no hedging. In Case 1, if the dairy farms have had taken a short position in Class III milk futures routinely over the past years, 33 of the 36 farms would have a lower variance of the farm profit. Among the 33 farms, 16 of them would have achieved a higher mean of the farm profit at the same time. The above results are more significant in Case 2 when measurement is scaled to per cwt. of milk. 31 farms in the sample would have both a reduced variance and a higher average farm profit if they have had short Class III milk futures. Hedging with corn futures would not have decreased the variance of the farm profit from 1997 to 2010 for any of the farm but would have increased the mean of the farm profit for every farm in Case 2 and 35 out of 36 farms in Case 1. The results from hedging with Class III milk futures and corn futures simultaneously are similar to hedging costs of corn alone: the average farm profit increases for all the sample farms while the standard deviation is higher for 35 out of 36 farms in both Case 1 and Case 2.

Second, we compare hedging with the proposed ratio futures contracts R1 or R2 with hedging with milk and/or corn futures. Hedging with proposed futures contract R1 or R2 would have been effective strategies for managing farm profit. Every farm would have achieved both a reduced variance and an increased mean of the farm profit if the dairy producer has had taken a short position in either R1 futures or R2 futures in Case 2 and with the exception of five farms in Case 1. If the dairy producer is expected to maximize his or her utility under the mean-variance decision making framework, hedging with R1 or R2 futures would make the dairy producer better off than no hedging. Moreover, for every farm in the sample in Case 2, either short R1 futures or short R2 futures, the average farm profit would be higher and standard deviation lower compared to short Class III milk futures. Hedging with R2 futures would have contributed both a higher mean and lower variance compared to hedging with R1 futures. This is reasonable because by definition, R1 futures only hedge the price risk of part of the feed while R2 futures hedge almost all the feed costs.

Generally speaking, short R2 futures dominates all the other strategies for almost all the sample farms in both mean and variance except "short milk and long corn" strategy, which achieves a higher variance compensated by a higher average net farm profit. As discussed above, the optimal strategy could not be recognized without further quantitative analysis characterizing the risk profile and utility function of dairy producer. However, if the dairy producer's hedging objective is to reduce the variance of net return while maintaining the average farm profit level compared to no hedging, hedging with the ratio futures would achieve this objective for the dairy farms in the sample.

Last but not the least, short milk and long corn simultaneously and short milk to corn price ratio futures yield very different results even though the objectives of both strategies are protecting the profit margin from milk sales over costs of corn. For all the farms in the sample in Case 2, hedging with milk to corn price ratio futures result in lower variance and higher mean compared to no hedging. Hedging with milk and corn futures simultaneously result in higher variance and higher mean compared to no hedging with the exception of one sample farm. Thus, short R1 futures is a more mean-variance efficient strategy than no hedging while short milk and long corn simultaneously may not necessarily dominate the no hedging scenario.

It should be acknowledged that the optimal hedge ratios are estimated using market data rather than the farm data based on the theoretical model. In principle, the estimated hedge ratios might not minimize the variance for a particular farm that faces prices that differ from the market averages.

As a general recommendation based on the results from the 36 New York dairy farms, short Class III milk futures are effective in reducing the variance of farm profit with lower expected return in most cases. Long corn futures do not reduce the variance of farm profit for most dairy farms from the model established in this thesis. This is possible because hedging feed costs only is more likely to reduce the variance of feed costs rather than the variance of farm profit. By taking a short position in either of the proposed ratio futures, dairy farms in our sample achieve the results of lower risk and higher return compared to no hedging scenario. Milk to feed price ratio futures seem to further decrease the variance of farm profit and increase the return than the milk to corn price ratio futures in hedging price risks.

5.3 Limitations

We need to be cautious summarizing the implications from results due to constraints on both data and the selection of applicable methods.

From a statistical perspective, there are two problems in generalizing the historical sample to future years. One is sampling error. For example, if we go back to

The existence of basis risk, the feed costs structure chosen and sample bias may contribute to the inaccuracy and non-representative of the results. The limitations of results are discussed more in details as follows.

(1) Basis risk

Average basis of milk price from annual observations are computed and shown as follows. The mean and variance of the basis between Class III milk nearby futures prices and New York all milk prices is 1.88 $/cwt. and 1.67. The average basis between Class III milk nearby futures prices and the net milk prices received by individual farmers is calculated for each sample farm, ranging from 0.61 $/cwt. to 2.26 $/cwt. The mean and variance of the basis for all the sample farms is 1.54 $/cwt. and 0.68 respectively. As mentioned in previous chapters, perfect hedge is hardly possible since the futures price and local cash price are not perfectly correlated. But the estimated hedge ratios, if properly modeled and estimated, take account of basis risk. In this thesis, however, hedge ratios are estimated using market data rather than farm specific data. Basis risk may not be fully captured for farms with prices that different from the market prices.

(2) Feed costs structure assumption

The feed costs structure adopted for all sample farms in this work is based on the USDA feed ration, which assumes that the mixed dairy feed consists of 51 pounds of corn, 8 pounds of soybeans and 41 pounds of alfalfa hay. The advantage of this measurement is its simplicity to calculate. However, it is not representative of an actual dairy ration since most milk producers feed soybean meal, not just soybeans (some use roasted soybeans), and most rations also consist of byproducts (Bailey and Ishler).

In addition, the assumption of feed efficiency as identical across farms and milking cows is an estimate that may not be accurate. In reality, feed efficiencies vary quite a lot for different producers with various feed components.

(3) Sample errors

The sample dataset features dairy farms with relative large herd size, higher net milk price received and higher net farm income among New York State dairy farms. As a result, the population of the sample is not all New York State dairy producers, but a population of relatively large dairy farms. Sampling error might be caused since only the sample dairy farms are analyzed instead of the whole population.

(4) Structural change in the sample period

Generalizing the historical sample to future years does not consider the potential structural change in the sample period. The parameters of the data generating process for milk, corn and soybean prices may have changed. In particular, spot prices for corn and soybean are varying around a larger mean with higher volatility. Then, a Monte-Carlo model would allow for this change. It would also be a better method in achieving the outcomes for a given structure by singling out the effects of noises from empirical data.

(5) Estimation of optimal hedge ratios

First, we should be cautious about the validation of empirical results using the point estimates for h_3 and h_4. The standard deviations of the estimated hedge ratios for short milk-corn futures and milk-feed futures are large. The 95% confidence interval for h_4 ranges from negative to positive.

Second, we assume hedges are placed once a year. To achieve this in real world, dairy producers are assumed to roll over the monthly futures contracts. In other words, the futures contracts held by dairy producers are always the nearby futures contracts. However, the hedge ratio parameters should not be constant over the sample period hedging with monthly contracts. Since the profits or losses are measured on an annual basis, this may not be a serious problem but a potential impreciseness.

(6) Lumpiness of futures contracts

The sizes of Class III milk, corn and soybean futures contracts[20] are lumpy. Consequently, the actual futures position would not match the optimum exactly in reality. For example, if a dairy producer is expecting to produce 9,000,000 pounds of milk in the coming year, an optimal hedge ratio of 0.8 would mean an optimal position of 7,200,000 pounds in futures. However, the position has to be adjusted to either 6,000,000 pounds (3 Class III milk futures) or 8,000,000 pounds (4 Class III milk futures), which will not achieve the theoretical optimum.

[20] Class III milk futures contract is 200,000 pounds each. Corn and soybean futures contracts are 5,000 bushels each.

Chapter 6 SUMMARY AND CONCLUSION

This thesis proposed two futures contract. One is the milk-to-corn price ratio futures contract. The other is the milk-to-feed price ratio futures contract. Both futures are designed to serve as a potential alternative to hedge the profit margin for dairy producers compared to traditional hedging using Class III milk futures, corn futures or soybean futures.

To examine the effectiveness of the proposed price ratio futures contracts in managing price risks and protecting profit margin, farm profits under different hedging scenarios are being calculated and compared based on a sample of 36 New York dairy farms from 1997 to 2010. This objective is achieved with the following steps.

1. A simple farm profit model is established. Net farm profit is calculated as milk sales over feed costs and operating costs.
2. Some assumptions are made. Feed costs are constructed on the basis of per cwt. of milk from estimating feed ration and feed efficiency. All sample farms adopt the same feed costs. Operating costs are also estimated on the basis of per cwt. of milk. Each farm adopts different operating costs estimated from historical average.
3. Farm profit models of six scenarios are created. The base scenario is no hedging. The five hedging scenarios are short Class III milk futures, long corn futures, short Class III milk futures and long corn futures simultaneously, short

milk-corn price ratio futures and short milk-feed price ratio futures. An optimal hedge ratio is derived for each scenario. The hedge ratios of all sample farms are estimated to be the same under each scenario.

4. Farm profits are calculated as both net farm profit of the whole farm and net farm profit per cwt. of milk. Compare the mean and standard deviation of farm profits under six scenarios for each farm.

The empirical results from the sample data can be summarized as the following points.

1. Class III milk futures are effective in reducing the variance of farm profit with lower expected return in most cases.
2. Long corn futures do not reduce the variance of farm profit for most dairy farms from the model established in this thesis, but increase the average return of the farm.
3. By taking a short position in either of the proposed ratio futures, dairy farms in the sample achieve the results of both lower risk and higher return compared to no hedging scenario.
4. Milk-to-feed price ratio futures achieve an even lower variance and higher expected return than milk-to-corn price ratio futures from sample data.
5. Short milk-to-corn price ratio futures is a more mean-variance efficient strategy than no hedging while short milk and long corn simultaneously may

not necessarily dominate the no hedging scenario while both strategies are hedging against the price risks of milk and corn.

The limitations of results should be acknowledged due to basis risk, sample bias, estimation error of the hedge ratios and strong assumptions in establishing the feed costs structure for dairy producers. It is also important to realize that the actual futures position would not match the optimum exactly in reality due to the lumpiness of futures contracts.

In the real world, costs of hedging is a crucial consideration for hedging decisions. The potential benefit of a ratio contract is the reduced transaction fees of using one market instrument rather than two. In addition, margin calls for a ratio contract could be much smaller than margin calls for a milk and/or corn contract. Particularly in the occasion, for example, when futures price of milk increases while futures price of corn decrease, it is extremely difficult for dairy producers to fulfill the margin call requirements. The magnitude of changes in the price of ratio contract would be much smaller in this situation and thus calls for less deposits from margin calls.

The stochastic processes of the proposed futures contracts are developed in the thesis using geometric Brownian motion. Pricing the option on milk-to-corn price ratio futures and milk-to-feed price ratio futures under no-arbitrage market condition would be an interesting topic to explore in future research.

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APPENDIX

1. Derivation of the stochastic process followed by R1

Nearby futures prices of Class III milk futures, corn futures and soybean futures follow geometric Brownian motion.

$$\frac{dm_t}{m_t} = \mu_m dt + \sigma_m dz_m \tag{1}$$

$$\frac{dc_t}{c_t} = \mu_c dt + \sigma_c dz_c \tag{2}$$

$$\frac{ds_t}{s_t} = \mu_s dt + \sigma_s dz_s \tag{3}$$

Applying Ito's lemma gives,

$$d(lnm_t) = (\mu_m - \frac{1}{2}\sigma_m^2)dt + \sigma_m dz_m \tag{4}$$

Thus,

$$m_t = m_{t-1}\, exp\left((\mu_m - \frac{1}{2}\sigma_m^2)dt + N(0,1)\sigma_m\sqrt{dt}\right) \tag{5}$$

$$c_t = c_{t-1}\, exp\left((\mu_c - \frac{1}{2}\sigma_c^2)dt + N(0,1)\sigma_c\sqrt{dt}\right) \tag{6}$$

$$s_t = s_{t-1}\, exp\left((\mu_s - \frac{1}{2}\sigma_s^2)dt + N(0,1)\sigma_s\sqrt{dt}\right) \tag{7}$$

where $N(0,1)$ are correlated random shocks.

The process followed by $R_1 = \frac{m}{c}$ is given by,

$$dR = \frac{\partial R}{\partial m}dm + \frac{\partial R}{\partial c}dc + \frac{\partial^2 R}{\partial m \partial c}dmdc \tag{8}$$

Since,

$$\frac{\partial R_t}{\partial m_t} = \frac{1}{c_t} \tag{9}$$

$$\frac{\partial R_t}{\partial c_t} = -\frac{m_t}{c_t^2} \tag{10}$$

$$\frac{\partial^2 R_t}{\partial m_t \partial c_t} = -\frac{1}{c_t^2} \tag{11}$$

$$dm_t = \mu_m m_t dt + \sigma_m m_t dz_m \tag{12}$$

$$dc_t = \mu_c c_t dt + \sigma_c c_t dz_c \quad (13)$$

Substitute (9) – (13) into (8),

$$\begin{aligned} dR_t = \frac{1}{c_t}(\mu_m m_t dt + \sigma_m m_t dz_m) - \frac{m_t}{c_t^2}(\mu_c c_t dt + \sigma_c c_t dz_c) \\ - \frac{1}{c_t^2}(\mu_m m_t dt + \sigma_m m_t dz_m)(\mu_c c_t dt + \sigma_c c_t dz_c) \end{aligned} \quad (14)$$

By definition,

$$dz_m\, dz_c = \rho_{mc} dt$$

$$dz_m^2 = dt$$

$$dz_c^2 = dt$$

$$dz_m\, dt = 0$$

$$dz_c\, dt = 0$$

$$dt^2 = 0$$

where ρ_{mc} is the coefficient of correlation between the two processes of milk and corn futures prices.

Then, (14) can be written as,

$$\begin{aligned} dR_t = \frac{m_t}{c_t}(\mu_m dt + \sigma_m dz_m) - \frac{m_t}{c_t}(\mu_c dt + \sigma_c dz_c) \\ - \frac{m_t}{c_t}(\mu_m \mu_c dt^2 \\ + \mu_m \sigma_c dz_c dt + \mu_c \sigma_m dz_m dt + \sigma_m \sigma_c dz_m dz_c) \end{aligned} \quad (15)$$

$$\frac{dR_t}{R_t} = (\mu_m - \mu_c - \sigma_m \sigma_c \rho_{mc})dt + \sigma_m dz_m - \sigma_c dz_c \quad (16)$$

R_1 follows Ito's process. Thus,

$$\begin{aligned} \widetilde{R_{1,t}} = \widetilde{R_{1,t-1}}\, exp((\mu_m - \mu_c - \sigma_m \sigma_c \rho_{mc})\, dt \\ + N(0,1)\sigma_m \sqrt{dt} - N(0,1)\sigma_c \sqrt{dt}) \end{aligned} \quad (17)$$

2. Derivation of the stochastic process followed by R2

Similar to the derivation for R_1 based on milk-corn price ratio, apply Ito's lemma,

$$dR = \frac{\partial R}{\partial m}dm + \frac{\partial R}{\partial c}dc + \frac{\partial R}{\partial s}ds + \frac{\partial^2 R}{\partial m \partial c}dmdc + \frac{\partial^2 R}{\partial m \partial s}dmds + \frac{\partial^2 R}{\partial c \partial s}dcds \tag{18}$$

Plug in each term,

$$\begin{aligned} dR_t = {} & \frac{m_t}{\alpha c_t + (1-\alpha)s_t}(\mu_m dt + \sigma_m dz_m) \\ & - \frac{\alpha m_t c_t}{(\alpha c_t + (1-\alpha)s_t)^2}(\mu_c dt + \sigma_c dz_c) \\ & - \frac{(1-\alpha)m_t s_t}{(\alpha c_t + (1-\alpha)s_t)^2}(\mu_s dt + \sigma_s dz_s) \\ & - \frac{\alpha m_t c_t}{(\alpha c_t + (1-\alpha)s_t)^2}(\mu_m dt + \sigma_m dz_m)(\mu_c dt \\ & + \sigma_c dz_c) - \frac{(1-\alpha)m_t s_t}{(\alpha c_t + (1-\alpha)s_t)^2}(\mu_m dt \\ & + \sigma_m dz_m)(\mu_s dt + \sigma_s dz_s) \\ & + \frac{2\alpha(1-\alpha)m_t c_t s_t}{(\alpha c_t + (1-\alpha)s_t)^3}(\mu_c dt + \sigma_c dz_c)(\mu_s dt \\ & + \sigma_s dz_s) \end{aligned} \tag{19}$$

$$\begin{aligned} \frac{dR_t}{R_t} = {} & \Bigg(\mu_m - \frac{\alpha c_t}{\alpha c_t + (1-\alpha)s_t}(\mu_c \\ & + \sigma_m \sigma_c \rho_{mc}) - \frac{(1-\alpha)s_t}{\alpha c_t + (1-\alpha)s_t}(\mu_s + \sigma_m \sigma_s \rho_{ms}) \\ & + \frac{2\alpha(1-\alpha)c_t s_t}{(\alpha c_t + (1-\alpha)s_t)^2}\sigma_c \sigma_s \rho_{cs}\Bigg)dt + \sigma_m dz_m \\ & - \frac{\alpha c_t}{\alpha c_t + (1-\alpha)s_t}\sigma_c dz_c - \frac{(1-\alpha)s_t}{\alpha c_t + (1-\alpha)s_t}\sigma_s dz_s \end{aligned} \tag{20}$$

R_2 follows Ito's process. Thus,

$$\widetilde{R_{2,t}} = \widetilde{R_{2,t-1}}\, exp\left((\mu_m - \frac{\alpha c_t}{\alpha c_t + (1-\alpha)s_t}(\mu_c + \sigma_m\sigma_c\rho_{mc}) - \frac{(1-\alpha)s_t}{\alpha c_t + (1-\alpha)s_t}(\mu_s + \sigma_m\sigma_s\rho_{ms}) + \frac{2\alpha(1-\alpha)c_t s_t}{(\alpha c_t + (1-\alpha)s_t)^2}\sigma_c\sigma_s\rho_{cs})dt + N(0,1)\sigma_m\sqrt{dt} - N(0,1)\frac{\alpha c_t}{\alpha c_t + (1-\alpha)s_t}\sigma_c\sqrt{dt} - \frac{(1-\alpha)s_t}{\alpha c_t + (1-\alpha)s_t}\sigma_s\sqrt{dt} \right) \quad (21)$$

where,

$$c_t = c_{t-1}\, exp\left((\mu_c - \frac{1}{2}\sigma_c^2)dt + N(0,1)\sigma_c\sqrt{dt} \right)$$

$$s_t = s_{t-1}\, exp\left((\mu_s - \frac{1}{2}\sigma_s^2)dt + N(0,1)\sigma_s\sqrt{dt} \right)$$

3. Testing the pricing models for R1 and R2 with simulated data

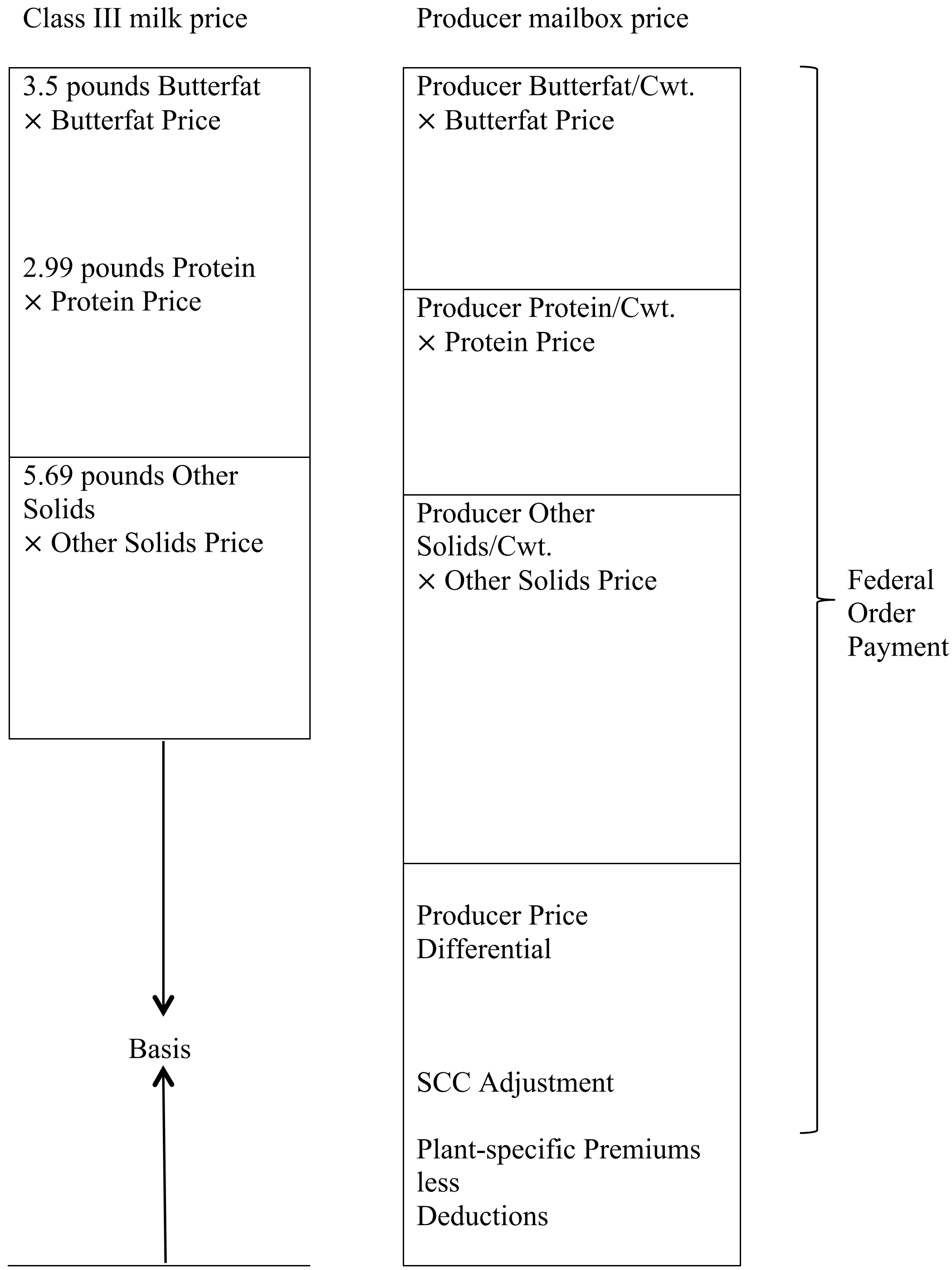
A monte-carlo simulation approach is used to verify the feasibility of R1 and R2 futures contracts. First, price series of milk, corn and soybean futures are generated from geometric Brownian motion by assuming random values to the drift and volatility terms. Second, calculate the correlation coefficient among milk, corn and soybean from the nearby futures price series for Class III milk, corn and soybean on the CME. By using the correlate time series function in @risk, the random shock correlates milk, corn and soybean prices, with the correlation coefficient result shown in Table 5.

Table 5. Correlation Coefficient Matrix for Class III Milk, Corn and Soybean Price

	Class III milk	Corn	Soybean
Class III milk	1		
Corn	0.47	1	
Soybean	0.48	0.89	1

Then, two price series are generated for contract R1 (R2). One series is generated directly from the newly derived process $\widetilde{R_{1,t}}$ ($\widetilde{R_{2,t}}$); another is generated by taking the ratio of the price series of milk to corn (milk to feed). It shows that the two price series are always identical under each simulation. Thus, the stochastic processes derived for R1 (R2) futures contracts are valid and effective.

4. Relationship between Class III milk price and producer's mailbox price by Jesse and Cropp



5. Monthly nearby futures prices of Class III milk, corn, soybean, R1 and R2

date	Milk ($/cwt)	Corn ($/cwt)	Soybean ($/cwt)	R1	R2
Jan-96	12.19	6.47	12.25	1.88	1.68
Feb-96	12.36	6.69	12.17	1.85	1.66
Mar-96	12.72	7.03	12.05	1.81	1.65
Apr-96	13.37	8.11	13.17	1.65	1.52
May-96	14.36	8.84	13.40	1.63	1.52
Jun-96	15.39	8.37	12.91	1.84	1.71
Jul-96	17.66	8.34	13.10	2.19	2.01
Aug-96	18.26	6.51	13.44	2.81	2.45
Sep-96	19.89	6.11	13.49	3.28	2.81
Oct-96	16.53	5.07	11.78	3.25	2.76
Nov-96	13.25	4.79	11.58	2.77	2.32
Dec-96	12.57	4.76	11.67	2.64	2.21
Jan-97	12.96	4.79	12.16	2.71	2.24
Feb-97	13.80	5.01	12.72	2.75	2.28
Mar-97	13.95	5.44	13.87	2.56	2.12
Apr-97	12.66	5.34	14.21	2.37	1.93
May-97	11.85	5.06	14.51	2.34	1.87
Jun-97	11.36	4.75	13.82	2.39	1.90
Jul-97	11.10	4.55	12.75	2.44	1.96
Aug-97	11.54	4.69	12.14	2.46	2.03
Sep-97	12.55	4.72	11.58	2.66	2.22
Oct-97	12.87	5.02	11.37	2.57	2.19
Nov-97	12.75	4.93	12.04	2.59	2.16
Dec-97	12.96	4.75	11.55	2.73	2.29
Jan-98	13.19	4.84	11.16	2.73	2.32
Feb-98	13.25	4.80	11.22	2.76	2.34
Mar-98	12.81	4.75	10.89	2.70	2.30
Apr-98	12.16	4.44	10.66	2.74	2.30
May-98	11.21	4.34	10.71	2.58	2.16
Jun-98	12.75	4.32	10.48	2.95	2.47
Jul-98	14.45	4.11	10.54	3.52	2.90
Aug-98	15.28	3.68	9.17	4.15	3.46
Sep-98	15.20	3.58	8.77	4.25	3.55
Oct-98	15.91	3.91	9.11	4.08	3.45
Nov-98	16.59	3.91	9.52	4.24	3.55
Dec-98	17.17	3.85	9.29	4.46	3.74
Jan-99	15.80	3.87	8.85	4.08	3.48
Feb-99	12.24	3.83	8.15	3.19	2.77
Mar-99	11.18	3.92	7.94	2.85	2.50
Apr-99	11.59	3.89	8.05	2.98	2.60
May-99	11.34	3.89	7.78	2.91	2.57

Jun-99	11.59	3.88	7.71	2.99	2.63
Jul-99	13.41	3.43	7.18	3.92	3.41
Aug-99	15.79	3.81	7.80	4.15	3.63
Sep-99	15.91	3.69	8.19	4.32	3.70
Oct-99	12.56	3.59	8.08	3.49	2.99
Nov-99	10.61	3.49	7.76	3.04	2.60
Dec-99	9.76	3.46	7.71	2.83	2.42
Jan-00	10.04	3.86	8.18	2.61	2.26
Feb-00	9.68	3.92	8.43	2.47	2.14
Mar-00	9.60	4.06	8.66	2.37	2.05
Apr-00	9.50	4.06	8.94	2.34	2.01
May-00	9.45	4.21	9.11	2.24	1.94
Jun-00	9.58	3.71	8.48	2.59	2.20
Jul-00	10.60	3.24	7.69	3.27	2.76
Aug-00	10.18	3.18	7.61	3.20	2.69
Sep-00	10.71	3.35	8.19	3.20	2.67
Oct-00	10.10	3.65	7.87	2.77	2.39
Nov-00	8.82	3.76	8.04	2.34	2.03
Dec-00	9.24	3.88	8.44	2.39	2.06
Jan-01	9.71	3.91	7.96	2.48	2.18
Feb-01	10.21	3.77	7.59	2.71	2.38
Mar-01	11.28	3.77	7.46	2.99	2.64
Apr-01	11.94	3.67	7.19	3.26	2.88
May-01	13.52	3.50	7.43	3.86	3.35
Jun-01	14.89	3.44	7.72	4.33	3.71
Jul-01	15.28	3.80	8.47	4.03	3.46
Aug-01	15.49	3.87	8.29	4.00	3.46
Sep-01	15.79	3.86	7.81	4.09	3.59
Oct-01	14.53	3.72	7.29	3.91	3.46
Nov-01	11.51	3.66	7.37	3.15	2.77
Dec-01	11.69	3.75	7.26	3.12	2.77
Jan-02	11.82	3.75	7.26	3.15	2.80
Feb-02	11.69	3.65	7.26	3.20	2.82
Mar-02	10.67	3.64	7.65	2.94	2.55
Apr-02	10.84	3.55	7.77	3.06	2.63
May-02	10.83	3.67	8.01	2.95	2.55
Jun-02	10.22	3.78	8.41	2.70	2.32
Jul-02	9.45	4.15	9.48	2.28	1.94
Aug-02	9.55	4.63	9.44	2.06	1.81
Sep-02	9.86	4.78	9.44	2.07	1.82
Oct-02	10.55	4.51	9.08	2.34	2.06
Nov-02	9.77	4.33	9.54	2.26	1.94
Dec-02	9.82	4.25	9.45	2.31	1.98
Jan-03	9.77	4.21	9.46	2.32	1.98
Feb-03	9.65	4.22	9.51	2.29	1.95

Mar-03	9.11	4.16	9.54	2.19	1.86
Apr-03	9.37	4.26	10.06	2.20	1.86
May-03	9.73	4.39	10.54	2.22	1.86
Jun-03	9.75	4.28	10.42	2.28	1.91
Jul-03	11.62	3.85	9.71	3.03	2.51
Aug-03	13.82	3.94	9.44	3.52	2.95
Sep-03	14.16	4.09	10.51	3.47	2.86
Oct-03	14.23	4.03	12.20	3.54	2.78
Nov-03	13.35	4.23	12.69	3.15	2.48
Dec-03	12.07	4.42	12.85	2.73	2.17
Jan-04	11.63	4.76	13.65	2.45	1.95
Feb-04	11.79	5.05	14.36	2.33	1.87
Mar-04	13.67	5.40	16.36	2.53	1.98
Apr-04	19.04	5.63	16.49	3.39	2.69
May-04	20.39	5.35	15.78	3.81	3.02
Jun-04	17.98	5.11	14.53	3.52	2.81
Jul-04	15.06	4.21	13.15	3.59	2.80
Aug-04	14.10	4.01	10.24	3.51	2.90
Sep-04	14.58	3.82	9.36	3.82	3.19
Oct-04	14.14	3.66	8.77	3.86	3.25
Nov-04	14.69	3.55	8.88	4.14	3.44
Dec-04	16.34	3.58	9.01	4.57	3.79
Jan-05	14.12	3.57	8.88	3.95	3.29
Feb-05	14.66	3.58	8.96	4.10	3.41
Mar-05	14.13	3.82	10.58	3.71	2.99
Apr-05	14.53	3.71	10.38	3.91	3.15
May-05	13.68	3.72	10.59	3.69	2.95
Jun-05	13.92	3.96	11.56	3.52	2.79
Jul-05	14.41	4.22	11.49	3.42	2.77
Aug-05	13.70	3.84	10.45	3.57	2.89
Sep-05	14.25	3.65	9.62	3.91	3.20
Oct-05	14.35	3.61	9.58	3.98	3.25
Nov-05	13.52	3.45	9.57	3.92	3.16
Dec-05	13.39	3.61	9.82	3.73	3.02
Jan-06	13.37	3.81	9.71	3.51	2.90
Feb-06	12.34	3.98	9.72	3.10	2.59
Mar-06	11.21	3.99	9.65	2.81	2.36
Apr-06	10.93	4.23	9.48	2.59	2.21
May-06	10.83	4.38	9.86	2.48	2.11
Jun-06	11.24	4.25	9.82	2.65	2.25
Jul-06	11.00	4.36	9.86	2.52	2.15
Aug-06	11.00	4.10	9.25	2.69	2.29
Sep-06	12.28	4.32	9.04	2.85	2.48
Oct-06	12.34	5.42	9.88	2.29	2.06
Nov-06	12.76	6.35	11.07	2.01	1.83

Dec-06	13.45	6.60	11.04	2.04	1.87
Jan-07	13.46	6.98	11.61	1.93	1.77
Feb-07	14.19	7.34	12.61	1.93	1.76
Mar-07	14.88	7.18	12.56	2.07	1.88
Apr-07	15.99	6.46	12.27	2.48	2.21
May-07	17.28	6.61	12.85	2.62	2.32
Jun-07	20.12	6.80	13.74	2.97	2.61
Jul-07	21.22	5.82	14.22	3.65	3.05
Aug-07	19.99	5.91	14.02	3.39	2.85
Sep-07	20.22	6.27	15.77	3.24	2.68
Oct-07	18.76	6.39	16.26	2.94	2.43
Nov-07	19.12	6.81	17.65	2.81	2.31
Dec-07	20.34	7.57	19.19	2.69	2.23
Jan-08	19.49	8.72	20.94	2.24	1.88
Feb-08	17.20	9.22	23.05	1.87	1.55
Mar-08	18.03	9.78	22.48	1.85	1.57
Apr-08	16.90	10.60	21.90	1.60	1.39
May-08	18.13	10.68	22.19	1.70	1.48
Jun-08	20.17	12.48	25.06	1.62	1.43
Jul-08	18.36	11.46	25.14	1.61	1.39
Aug-08	17.39	9.81	21.37	1.78	1.53
Sep-08	16.38	9.64	19.86	1.70	1.49
Oct-08	16.80	7.37	15.37	2.29	2.00
Nov-08	15.46	6.68	14.93	2.32	1.99
Dec-08	15.23	6.47	14.46	2.38	2.03
Jan-09	10.73	6.98	16.54	1.54	1.30
Feb-09	9.34	6.46	15.48	1.45	1.22
Mar-09	10.36	6.72	15.14	1.54	1.32
Apr-09	10.76	6.92	16.99	1.56	1.30
May-09	9.82	7.46	19.16	1.32	1.09
Jun-09	9.90	7.37	20.19	1.35	1.09
Jul-09	10.01	5.93	18.06	1.69	1.33
Aug-09	11.14	5.84	18.55	1.91	1.47
Sep-09	11.94	5.76	15.83	2.08	1.68
Oct-09	12.79	6.64	16.10	1.93	1.62
Nov-09	14.02	6.96	16.82	2.01	1.69
Dec-09	14.70	7.06	17.20	2.08	1.74
Jan-10	14.40	6.89	16.28	2.10	1.77
Feb-10	14.27	6.48	15.63	2.20	1.85
Mar-10	13.07	6.49	15.83	2.01	1.68
Apr-10	12.88	6.32	16.22	2.04	1.68
May-10	13.30	6.51	15.83	2.04	1.71
Jun-10	13.54	6.19	15.81	2.19	1.81
Jul-10	13.75	6.69	16.83	2.06	1.71
Aug-10	15.07	7.30	17.21	2.07	1.75

Sep-10	16.17	8.62	17.70	1.88	1.64
Oct-10	16.80	9.74	19.38	1.73	1.53
Nov-10	15.72	9.86	20.86	1.60	1.39
Dec-10	13.90	10.46	21.94	1.33	1.16

6. Net farm profit of 36 sample farms (dollar return per year)

sample farm	*year*	*no hedge*	*short milk*	*long corn*	*short milk and long corn*	*short R1*	*short R2*
1	***1997***	107,433	172,900	88,354	129,748	98,148	103,790
	1998	238,978	187,352	230,662	131,946	200,628	192,704
	1999	310,745	380,288	302,722	381,324	313,768	306,132
	2000	247,411	392,454	247,575	459,302	300,077	312,652
	2001	367,920	195,040	367,662	115,121	304,279	287,057
	2002	183,624	348,041	191,607	453,669	262,491	279,422
	2003	180,465	123,045	182,792	105,738	168,600	179,675
	2004	435,721	206,988	443,310	131,611	377,475	375,184
	2005	469,489	550,777	450,348	514,611	441,187	437,967
	2006	268,997	399,565	289,849	539,009	365,608	361,877
	2007	719,401	310,376	770,468	319,133	709,102	707,575
	2008	518,296	557,286	596,298	873,708	604,187	619,070
	2009	178,719	793,043	75,326	677,694	206,951	224,116
	2010	797,874	407,899	844,226	407,304	758,390	742,451
	mean	**358,934**	**358,932**	**362,943**	**374,280**	**365,064**	**366,405**
	std	**207,874**	**184,463**	**236,317**	**235,783**	**199,836**	**196,411**
2	***1997***	215,309	310,127	187,676	247,629	201,862	210,034
	1998	298,423	234,636	288,148	166,176	251,038	241,248
	1999	304,872	365,501	297,878	366,404	307,508	300,851
	2000	223,431	340,172	223,563	393,977	265,820	275,942
	2001	335,135	204,281	334,940	143,791	286,965	273,930
	2002	180,401	300,208	186,217	377,178	237,870	250,207
	2003	196,042	150,615	197,883	136,923	186,655	195,418
	2004	334,613	169,142	340,104	114,612	292,477	290,819
	2005	367,670	430,398	352,900	402,490	345,830	343,345
	2006	212,737	312,761	228,711	419,583	286,747	283,889
	2007	539,338	265,577	573,517	271,438	532,445	531,423
	2008	395,464	420,409	445,367	622,846	450,415	459,937
	2009	89,203	354,102	44,619	304,363	101,377	108,779
	2010	347,596	215,609	363,284	215,408	334,233	328,838
	mean	**288,588**	**290,967**	**290,343**	**298,773**	**291,517**	**292,476**

	std	**112,343**	**87,985**	**129,065**	**142,023**	**106,963**	**105,315**
3	***1997***	2,294	19,704	(2,780)	8,228	(175)	1,325
	1998	22,033	10,013	20,097	(2,887)	13,104	11,259
	1999	27,060	39,320	25,645	39,503	27,593	26,247
	2000	1,637	27,825	1,666	39,896	11,146	13,417
	2001	24,395	(1,990)	24,356	(14,188)	14,682	12,054
	2002	(11,137)	10,567	(10,084)	24,511	(726)	1,509
	2003	(6,253)	(14,036)	(5,938)	(16,381)	(7,861)	(6,360)
	2004	26,474	(2,339)	27,430	(11,834)	19,137	18,848
	2005	23,822	33,587	21,523	29,243	20,422	20,035
	2006	(2,773)	13,016	(251)	29,878	8,910	8,459
	2007	47,976	1,976	53,719	2,961	46,818	46,646
	2008	22,224	26,461	30,700	60,843	31,557	33,174
	2009	(17,597)	31,393	(25,842)	22,194	(15,346)	(13,977)
	2010	16,238	(7,441)	19,052	(7,477)	13,840	12,873
	mean	**12,599**	**13,433**	**12,807**	**14,606**	**13,079**	**13,251**
	std	**18,411**	**16,741**	**20,719**	**23,953**	**16,215**	**15,672**
4	***1997***	886,037	1,324,447	758,272	1,035,474	823,862	861,644
	1998	1,511,198	1,207,103	1,462,214	880,736	1,285,300	1,238,626
	1999	1,744,341	2,069,801	1,706,794	2,074,648	1,758,490	1,722,754
	2000	1,387,854	2,042,518	1,388,593	2,344,246	1,625,568	1,682,327
	2001	2,184,927	1,402,471	2,183,760	1,040,761	1,896,888	1,818,941
	2002	1,501,844	2,191,303	1,535,318	2,634,237	1,832,563	1,903,558
	2003	1,602,031	1,313,760	1,613,715	1,226,874	1,542,464	1,598,067
	2004	2,963,318	1,801,586	3,001,864	1,418,747	2,667,487	2,655,850
	2005	3,022,758	3,430,067	2,926,848	3,248,852	2,880,945	2,864,809
	2006	2,040,040	2,769,059	2,156,466	3,547,631	2,579,463	2,558,629
	2007	4,274,125	2,153,276	4,538,914	2,198,682	4,220,722	4,212,808
	2008	2,888,010	3,066,880	3,245,852	4,518,504	3,282,048	3,350,325
	2009	1,395,989	3,761,506	997,863	3,317,343	1,504,698	1,570,797
	2010	3,194,564	1,953,330	3,342,097	1,951,436	3,068,893	3,018,160
	mean	**2,185,503**	**2,177,651**	**2,204,184**	**2,245,584**	**2,212,099**	**2,218,378**
	std	**944,887**	**806,568**	**1,066,884**	**1,102,292**	**929,488**	**920,709**
5	***1997***	374,739	597,849	309,718	450,789	343,097	362,325
	1998	636,817	475,214	610,786	301,776	516,769	491,966
	1999	725,804	878,506	708,188	880,780	732,443	715,676
	2000	514,937	840,681	515,305	990,814	633,217	661,459
	2001	1,035,415	605,150	1,034,774	406,250	877,025	834,163
	2002	635,943	1,026,454	654,903	1,277,334	823,263	863,475
	2003	663,140	507,104	669,464	460,074	630,897	660,994

	2004	1,141,569	545,697	1,161,340	349,333	989,832	983,864
	2005	1,185,147	1,393,788	1,136,018	1,300,962	1,112,505	1,104,239
	2006	868,067	1,244,034	928,110	1,645,555	1,146,256	1,135,512
	2007	2,128,751	1,019,246	2,267,273	1,043,000	2,100,814	2,096,673
	2008	1,621,666	1,726,048	1,830,489	2,573,161	1,851,611	1,891,455
	2009	465,603	1,694,834	258,718	1,464,026	522,093	556,441
	2010	1,330,705	742,262	1,400,647	741,364	1,271,127	1,247,075
	mean	**952,022**	**949,776**	**963,267**	**991,801**	**967,925**	**971,809**
	std	**494,242**	**424,197**	**569,354**	**633,250**	**504,779**	**503,433**
6	***1997***	241,950	367,079	205,484	284,602	224,205	234,988
	1998	450,395	357,435	435,421	257,666	381,339	367,071
	1999	399,294	488,807	388,967	490,140	403,185	393,357
	2000	301,347	474,877	301,543	554,855	364,357	379,402
	2001	562,795	343,517	562,468	242,150	482,074	460,230
	2002	268,453	443,191	276,937	555,450	352,271	370,265
	2003	277,390	214,998	279,919	196,193	264,498	276,532
	2004	529,685	291,981	537,572	213,648	469,155	466,773
	2005	549,889	638,681	528,982	599,177	518,975	515,457
	2006	329,518	487,248	354,708	655,699	446,227	441,720
	2007	820,022	355,430	878,026	365,376	808,323	806,590
	2008	577,746	618,140	658,556	945,955	666,730	682,149
	2009	155,183	650,517	71,816	557,510	177,947	191,787
	2010	528,135	284,894	557,047	284,523	503,508	493,566
	mean	**427,986**	**429,771**	**431,246**	**443,067**	**433,057**	**434,278**
	std	**178,400**	**137,307**	**206,908**	**216,177**	**167,235**	**163,765**
7	***1997***	171,289	259,335	145,630	201,301	158,802	166,390
	1998	310,618	244,818	300,019	174,198	261,738	251,639
	1999	285,161	344,165	278,354	345,044	287,726	281,248
	2000	230,859	346,548	230,990	399,868	272,867	282,897
	2001	398,356	253,812	398,140	186,993	345,146	330,747
	2002	208,143	334,142	214,260	415,089	268,582	281,556
	2003	227,705	180,266	229,628	165,968	217,902	227,053
	2004	421,357	226,751	427,814	162,620	371,801	369,852
	2005	422,049	488,884	406,311	459,148	398,779	396,131
	2006	268,698	400,472	289,743	541,203	366,202	362,436
	2007	737,186	341,148	786,632	349,627	727,214	725,736
	2008	590,404	629,375	668,369	945,647	676,255	691,131
	2009	215,986	679,803	137,924	592,714	237,301	250,262
	2010	645,326	384,155	676,368	383,756	618,883	608,208

	mean	**366,653**	**365,263**	**370,727**	**380,227**	**372,086**	**373,235**
	std	**178,713**	**146,622**	**205,526**	**215,878**	**177,221**	**175,866**
8	***1997***	383,765	582,672	325,798	451,565	355,556	372,698
	1998	611,726	475,697	589,814	329,704	510,676	489,798
	1999	625,648	755,553	610,661	757,488	631,296	617,032
	2000	469,635	726,999	469,925	845,616	563,086	585,399
	2001	804,042	480,689	803,559	331,211	685,008	652,797
	2002	450,881	746,944	465,255	937,146	592,896	623,382
	2003	555,811	441,778	560,433	407,408	532,248	554,243
	2004	1,095,564	633,879	1,110,883	481,734	977,998	973,373
	2005	1,007,251	1,153,237	972,875	1,088,287	956,423	950,639
	2006	552,102	804,475	592,407	1,074,003	738,841	731,628
	2007	1,335,208	615,469	1,425,068	630,878	1,317,085	1,314,399
	2008	902,219	964,444	1,026,703	1,469,424	1,039,295	1,063,046
	2009	259,961	993,976	136,423	856,153	293,693	314,203
	2010	870,152	485,260	915,900	484,672	831,183	815,451
	mean	**708,855**	**704,362**	**714,693**	**724,664**	**716,092**	**718,435**
	std	**303,656**	**217,491**	**344,955**	**339,514**	**282,423**	**278,171**
9	***1997***	49,939	70,321	44,000	56,887	47,049	48,805
	1998	69,266	54,230	66,844	38,094	58,097	55,789
	1999	74,009	88,240	72,367	88,452	74,627	73,065
	2000	48,594	74,374	48,623	86,255	57,955	60,190
	2001	80,381	52,148	80,339	39,096	69,988	67,175
	2002	38,545	61,633	39,666	76,465	49,620	51,997
	2003	35,591	27,696	35,911	25,317	33,960	35,482
	2004	66,586	33,468	67,685	22,555	58,153	57,821
	2005	67,919	79,480	65,197	74,336	63,894	63,436
	2006	50,793	68,430	53,610	87,267	63,843	63,339
	2007	96,728	41,733	103,595	42,910	95,344	95,138
	2008	65,117	69,878	74,641	108,515	75,605	77,422
	2009	21,775	77,877	12,333	67,343	24,353	25,921
	2010	60,730	32,964	64,030	32,922	57,919	56,784
	mean	**58,998**	**59,462**	**59,203**	**60,458**	**59,315**	**59,455**
	std	**19,609**	**19,383**	**22,385**	**27,288**	**17,693**	**17,016**
10	***1997***	(32,792)	(20,933)	(36,248)	(28,750)	(34,474)	(33,452)
	1998	(16,765)	(25,563)	(18,182)	(35,005)	(23,301)	(24,651)
	1999	(18,643)	(10,880)	(19,539)	(10,765)	(18,306)	(19,158)
	2000	(36,888)	(21,184)	(36,870)	(13,946)	(31,186)	(29,824)
	2001	(16,522)	(35,258)	(16,550)	(43,919)	(23,419)	(25,285)

	2002	(43,245)	(25,977)	(42,407)	(14,883)	(34,962)	(33,184)
	2003	(53,251)	(59,541)	(52,996)	(61,436)	(54,551)	(53,338)
	2004	(14,586)	(38,343)	(13,798)	(46,172)	(20,636)	(20,874)
	2005	(21,569)	(13,728)	(23,416)	(17,217)	(24,299)	(24,610)
	2006	(47,127)	(32,914)	(44,857)	(17,735)	(36,610)	(37,017)
	2007	(6,308)	(44,336)	(1,561)	(43,522)	(7,266)	(7,408)
	2008	(35,866)	(32,917)	(29,967)	(8,985)	(29,370)	(28,244)
	2009	(48,046)	(17,790)	(53,139)	(23,471)	(46,656)	(45,810)
	2010	(24,895)	(38,887)	(23,232)	(38,909)	(26,312)	(26,884)
	mean	**(29,750)**	**(29,875)**	**(29,483)**	**(28,908)**	**(29,382)**	**(29,267)**
	std	**14,691**	**13,145**	**15,472**	**16,101**	**11,899**	**11,308**
11	***1997***	(487)	16,369	(5,400)	5,258	(2,878)	(1,425)
	1998	21,190	8,397	19,129	(5,334)	11,686	9,723
	1999	20,801	33,023	19,392	33,205	21,333	19,991
	2000	654	23,597	680	34,170	8,985	10,974
	2001	22,696	(3,115)	22,657	(15,047)	13,194	10,623
	2002	(4,983)	17,519	(3,890)	31,976	5,811	8,128
	2003	(9,045)	(17,352)	(8,708)	(19,856)	(10,761)	(9,159)
	2004	24,227	(9,075)	25,331	(20,049)	15,747	15,413
	2005	22,286	32,133	19,967	27,752	18,857	18,467
	2006	(3,554)	13,475	(835)	31,662	9,046	8,560
	2007	52,686	1,492	59,078	2,588	51,397	51,206
	2008	23,121	27,331	31,544	61,501	32,396	34,003
	2009	(27,047)	24,296	(35,688)	14,656	(24,687)	(23,252)
	2010	4,009	(19,546)	6,809	(19,582)	1,624	661
	mean	**10,468**	**10,610**	**10,719**	**11,636**	**10,839**	**10,994**
	std	**19,854**	**17,640**	**22,555**	**25,774**	**18,289**	**17,886**
12	***1997***	167,219	266,566	138,267	201,083	153,130	161,692
	1998	332,497	253,021	319,695	167,724	273,458	261,260
	1999	330,980	409,869	321,879	411,044	334,409	325,747
	2000	201,810	355,523	201,984	426,367	257,624	270,951
	2001	394,382	216,174	394,116	133,793	328,779	311,027
	2002	145,417	291,112	152,491	384,713	215,304	230,307
	2003	206,140	150,725	208,386	134,023	194,689	205,378
	2004	356,821	154,583	363,531	87,937	305,322	303,296
	2005	366,770	429,509	351,996	401,596	344,926	342,440
	2006	149,450	262,067	167,435	382,338	232,778	229,560
	2007	550,213	238,495	589,131	245,168	542,364	541,201
	2008	431,450	459,278	487,122	685,115	492,753	503,375

	2009	203,037	555,198	143,766	489,074	219,220	229,061
	2010	481,764	310,249	502,150	309,987	464,399	457,389
	mean	**308,425**	**310,883**	**310,139**	**318,569**	**311,368**	**312,334**
	std	**130,851**	**117,653**	**147,388**	**166,951**	**117,195**	**114,373**
13	***1997***	220,539	338,143	186,266	260,626	203,860	213,995
	1998	370,609	283,233	356,534	189,458	305,701	292,290
	1999	370,806	454,260	361,178	455,503	374,434	365,271
	2000	256,647	423,862	256,835	500,930	317,364	331,861
	2001	436,861	249,481	436,581	162,860	367,882	349,216
	2002	198,307	370,813	206,682	481,637	281,054	298,818
	2003	258,822	190,801	261,579	170,300	244,766	257,887
	2004	538,657	284,832	547,078	201,186	474,021	471,478
	2005	533,951	620,610	513,546	582,055	503,779	500,346
	2006	353,779	527,984	381,600	714,031	482,679	477,700
	2007	971,919	456,860	1,036,225	467,887	958,950	957,028
	2008	788,177	836,843	885,536	1,231,790	895,384	913,960
	2009	359,421	987,693	253,680	869,725	388,294	405,849
	2010	943,106	604,816	983,315	604,300	908,855	895,028
	mean	**471,543**	**473,588**	**476,188**	**492,306**	**479,073**	**480,766**
	std	**256,976**	**227,384**	**288,662**	**304,271**	**255,188**	**253,358**
14	***1997***	97,868	198,966	68,406	132,329	83,531	92,243
	1998	273,964	208,011	263,340	137,228	224,971	214,848
	1999	213,365	279,913	205,687	280,904	216,258	208,951
	2000	112,322	233,297	112,459	289,053	156,249	166,738
	2001	254,390	100,029	254,159	28,672	197,566	182,189
	2002	73,355	195,065	79,264	273,257	131,737	144,270
	2003	103,946	57,066	105,846	42,936	94,259	103,302
	2004	295,990	110,761	302,135	49,721	248,822	246,966
	2005	274,406	333,481	260,496	307,198	253,838	251,498
	2006	124,953	232,586	142,143	347,535	204,594	201,518
	2007	436,332	136,912	473,714	143,323	428,792	427,675
	2008	256,385	281,062	305,753	481,329	310,746	320,166
	2009	74,755	365,988	25,739	311,304	88,139	96,277
	2010	367,915	185,606	389,584	185,328	349,457	342,005
	mean	**211,425**	**208,482**	**213,480**	**215,008**	**213,497**	**214,189**
	std	**115,512**	**88,646**	**130,887**	**133,023**	**101,689**	**98,071**
15	***1997***	209,325	339,106	171,503	253,563	190,920	202,104
	1998	393,493	292,921	377,292	184,983	318,782	303,346
	1999	454,528	569,350	441,281	571,060	459,519	446,911

	2000	274,672	489,208	274,914	588,085	352,571	371,172
	2001	636,142	322,865	635,675	178,045	520,818	489,610
	2002	260,169	503,920	272,004	660,516	377,092	402,191
	2003	334,651	228,854	338,939	196,966	312,789	333,196
	2004	713,701	315,362	726,918	184,092	612,265	608,275
	2005	620,862	748,645	590,773	691,793	576,371	571,309
	2006	336,012	537,423	368,178	752,525	485,042	479,286
	2007	998,131	376,292	1,075,768	389,606	982,473	980,152
	2008	669,341	724,516	779,722	1,172,289	790,887	811,948
	2009	134,514	803,522	21,917	677,905	165,259	183,952
	2010	971,975	533,738	1,024,064	533,069	927,605	909,693
	mean	**500,537**	**484,694**	**507,068**	**502,464**	**505,171**	**506,653**
	std	**273,494**	**182,212**	**311,668**	**289,721**	**253,121**	**247,532**
16	***1997***	65,852	120,515	49,922	84,485	58,100	62,811
	1998	131,065	92,411	124,839	50,926	102,351	96,418
	1999	136,221	172,259	132,064	172,796	137,788	133,831
	2000	98,327	171,198	98,410	204,783	124,787	131,105
	2001	143,484	68,839	143,372	34,332	116,005	108,569
	2002	62,568	129,289	65,808	172,152	94,573	101,443
	2003	73,900	47,364	74,975	39,367	68,417	73,535
	2004	185,725	77,180	189,327	41,410	158,085	156,997
	2005	184,722	221,119	176,151	204,926	172,049	170,607
	2006	92,713	157,191	103,010	226,051	140,422	138,579
	2007	325,158	136,439	348,720	140,480	320,406	319,702
	2008	211,956	228,151	244,356	359,589	247,634	253,816
	2009	25,643	239,899	(10,418)	199,669	35,489	41,476
	2010	207,794	98,335	220,804	98,168	196,712	192,238
	mean	**138,938**	**140,014**	**140,096**	**144,938**	**140,915**	**141,509**
	std	**79,009**	**61,231**	**91,398**	**93,292**	**76,328**	**75,317**
17	***1997***	165,940	261,840	137,991	198,628	152,339	160,604
	1998	321,277	244,759	308,951	162,636	264,435	252,691
	1999	309,764	378,333	301,853	379,354	312,745	305,215
	2000	205,522	337,832	205,671	398,812	253,565	265,036
	2001	403,043	211,272	402,757	122,621	332,448	313,344
	2002	198,101	368,146	206,356	477,390	279,668	297,178
	2003	214,115	151,959	216,634	133,225	201,272	213,260
	2004	458,063	203,988	466,493	120,260	393,364	390,818
	2005	446,456	530,688	426,622	493,212	417,129	413,792
	2006	231,063	373,233	253,768	525,066	336,259	332,196

	2007	761,648	327,651	815,832	336,943	750,720	749,100
	2008	470,702	511,481	552,284	842,425	560,535	576,101
	2009	83,272	586,068	(1,351)	491,660	106,378	120,428
	2010	514,056	256,248	544,699	255,855	487,954	477,416
	mean	**341,644**	**338,821**	**345,611**	**352,721**	**346,343**	**347,656**
	std	**179,267**	**130,810**	**207,307**	**205,988**	**169,644**	**167,036**
18	***1997***	146,008	221,201	124,094	171,638	135,344	141,824
	1998	287,569	227,901	277,958	163,862	243,244	234,086
	1999	307,933	370,270	300,742	371,198	310,643	303,799
	2000	248,279	370,478	248,417	426,798	292,650	303,245
	2001	492,224	303,983	491,943	216,964	422,928	404,176
	2002	223,898	384,276	231,684	487,308	300,828	317,342
	2003	285,937	223,138	288,483	204,210	272,961	285,074
	2004	624,040	362,954	632,703	276,914	557,555	554,940
	2005	636,763	732,872	614,132	690,112	603,300	599,493
	2006	452,599	633,692	481,520	827,094	586,595	581,420
	2007	1,142,293	593,155	1,210,853	604,912	1,128,466	1,126,416
	2008	790,102	836,172	882,268	1,210,054	891,591	909,176
	2009	321,778	859,986	231,195	758,929	346,512	361,551
	2010	801,837	518,621	835,500	518,189	773,162	761,586
	mean	**482,947**	**474,193**	**489,392**	**494,870**	**490,413**	**491,723**
	std	**283,473**	**223,095**	**313,303**	**301,995**	**283,059**	**281,610**
19	***1997***	209,875	307,831	181,328	243,265	195,983	204,425
	1998	383,607	311,006	371,913	233,088	329,675	318,532
	1999	362,651	431,004	354,765	432,022	365,622	358,117
	2000	287,279	430,377	287,441	496,330	339,239	351,646
	2001	506,942	311,191	506,650	220,701	434,882	415,381
	2002	271,237	446,147	279,729	558,515	355,137	373,148
	2003	285,750	218,450	288,478	198,165	271,843	284,825
	2004	559,078	301,534	567,624	216,663	493,496	490,916
	2005	526,266	610,968	506,321	573,283	496,775	493,419
	2006	335,393	482,598	358,902	639,810	444,314	440,108
	2007	828,897	408,351	881,403	417,355	818,308	816,739
	2008	569,900	605,769	641,659	896,865	648,917	662,609
	2009	218,826	679,218	141,340	592,772	239,984	252,848
	2010	615,422	385,764	642,719	385,413	592,170	582,783
	mean	**425,795**	**423,586**	**429,305**	**436,018**	**430,453**	**431,821**
	std	**179,689**	**134,476**	**205,058**	**205,366**	**170,443**	**167,636**
20	***1997***	402,070	600,783	344,159	469,804	373,888	391,013

	1998	728,108	570,118	702,659	400,556	610,744	586,495
	1999	747,815	901,037	730,138	903,319	754,476	737,652
	2000	553,836	851,636	554,172	988,889	661,970	687,789
	2001	925,491	557,847	924,943	387,894	790,153	753,529
	2002	431,091	738,170	446,000	935,450	578,391	610,011
	2003	521,913	402,228	526,764	366,154	497,181	520,267
	2004	951,276	490,774	966,555	339,019	834,010	829,397
	2005	904,905	1,062,055	867,901	992,138	850,190	843,965
	2006	563,066	867,502	611,685	1,192,630	788,327	779,627
	2007	1,436,486	696,322	1,528,896	712,169	1,417,849	1,415,087
	2008	1,039,413	1,105,718	1,172,060	1,643,814	1,185,477	1,210,787
	2009	362,584	1,131,423	233,186	987,061	397,917	419,400
	2010	1,057,686	652,725	1,105,819	652,107	1,016,685	1,000,133
	mean	**758,981**	**759,167**	**765,353**	**783,643**	**768,376**	**770,368**
	std	**309,174**	**233,262**	**354,498**	**379,045**	**291,967**	**286,725**
21	***1997***	345,855	478,584	307,173	391,097	327,031	338,470
	1998	556,588	457,485	540,624	351,124	482,969	467,758
	1999	657,719	764,144	645,441	765,729	662,346	650,660
	2000	543,226	754,961	543,465	852,547	620,109	638,466
	2001	820,241	546,825	819,833	420,432	719,591	692,354
	2002	587,279	840,283	599,563	1,002,822	708,640	734,692
	2003	567,002	470,623	570,908	441,573	547,086	565,677
	2004	1,016,464	608,765	1,029,991	474,411	912,645	908,561
	2005	1,153,605	1,310,731	1,116,606	1,240,824	1,098,898	1,092,673
	2006	783,010	1,067,483	828,441	1,371,291	993,500	985,370
	2007	1,718,576	868,389	1,824,723	886,591	1,697,169	1,693,996
	2008	1,455,778	1,533,464	1,611,193	2,163,922	1,626,914	1,656,567
	2009	829,210	1,962,221	638,520	1,749,480	881,278	912,938
	2010	1,688,025	1,110,870	1,756,625	1,109,990	1,629,590	1,606,000
	mean	**908,756**	**912,488**	**916,651**	**944,417**	**921,983**	**924,584**
	std	**440,409**	**445,491**	**488,770**	**546,768**	**444,537**	**443,100**
22	***1997***	34,726	73,307	23,482	47,877	29,254	32,579
	1998	79,514	51,929	75,070	22,325	59,022	54,789
	1999	87,601	115,132	84,425	115,542	88,798	85,775
	2000	53,333	102,657	53,389	125,389	71,243	75,519
	2001	108,749	53,026	108,666	27,267	88,236	82,685
	2002	31,600	76,881	33,798	105,971	53,320	57,983
	2003	30,030	12,271	30,749	6,918	26,360	29,785
	2004	87,628	16,745	89,980	(6,614)	69,578	68,868

	2005	66,163	89,311	60,712	79,012	58,103	57,186
	2006	30,628	63,711	35,912	99,042	55,107	54,162
	2007	151,478	48,106	164,384	50,319	148,875	148,489
	2008	97,366	106,527	115,692	180,867	117,546	121,042
	2009	8,569	117,771	(9,810)	97,267	13,588	16,639
	2010	92,200	34,950	99,005	34,862	86,404	84,064
	mean	**68,542**	**68,737**	**68,961**	**70,432**	**68,960**	**69,255**
	std	**39,219**	**34,707**	**45,454**	**52,953**	**36,090**	**35,141**
23	***1997***	230,161	373,282	188,451	278,945	209,863	222,197
	1998	384,369	283,462	368,115	175,164	309,410	293,922
	1999	400,230	494,072	389,403	495,470	404,309	394,005
	2000	238,706	409,374	238,899	488,034	300,677	315,474
	2001	504,924	270,506	504,575	162,141	418,630	395,278
	2002	246,305	438,406	255,632	561,819	338,452	358,233
	2003	311,783	231,903	315,021	207,827	295,277	310,685
	2004	598,353	307,553	608,001	211,722	524,302	521,389
	2005	581,706	678,003	559,030	635,159	548,178	544,363
	2006	343,021	506,027	369,054	680,112	463,634	458,976
	2007	868,046	385,528	928,289	395,859	855,897	854,096
	2008	655,799	700,918	746,063	1,067,085	755,193	772,416
	2009	184,734	764,445	87,167	655,595	211,375	227,574
	2010	657,767	351,783	694,136	351,316	626,787	614,280
	mean	**443,279**	**442,519**	**446,560**	**454,732**	**447,285**	**448,778**
	std	**204,598**	**168,112**	**237,491**	**254,461**	**196,217**	**193,367**
24	***1997***	123,938	181,271	107,229	143,480	115,807	120,748
	1998	262,911	203,615	253,359	139,977	218,863	209,762
	1999	295,624	360,413	288,150	361,378	298,441	291,327
	2000	280,287	448,592	280,477	526,162	341,400	355,992
	2001	425,554	141,243	425,130	9,813	320,893	292,571
	2002	369,076	638,843	382,173	812,152	498,477	526,256
	2003	393,499	310,967	396,844	286,091	376,445	392,364
	2004	596,462	286,342	606,752	184,144	517,491	514,385
	2005	580,265	686,627	555,220	639,306	543,233	539,019
	2006	365,851	578,480	399,809	805,561	523,181	517,105
	2007	1,066,329	472,948	1,140,413	485,652	1,051,387	1,049,173
	2008	832,794	888,343	943,923	1,339,152	955,164	976,368
	2009	339,991	972,644	233,513	853,853	369,065	386,743
	2010	855,412	524,577	894,735	524,072	821,916	808,394
	mean	**484,857**	**478,207**	**493,409**	**507,914**	**496,555**	**498,586**

	std	**268,276**	**255,825**	**303,341**	**361,826**	**273,762**	**275,416**
25	***1997***	834,867	1,361,704	681,331	1,014,446	760,151	805,554
	1998	1,633,004	1,285,923	1,577,096	913,420	1,375,173	1,321,901
	1999	1,789,229	2,137,483	1,749,052	2,142,670	1,804,369	1,766,130
	2000	1,006,925	1,633,822	1,007,632	1,922,753	1,234,556	1,288,908
	2001	1,667,925	951,728	1,666,857	620,649	1,404,277	1,332,931
	2002	756,585	1,356,694	785,721	1,742,227	1,044,445	1,106,240
	2003	843,301	606,337	852,905	534,915	794,335	840,042
	2004	1,751,630	823,072	1,782,440	517,073	1,515,176	1,505,875
	2005	1,839,821	2,164,956	1,763,261	2,020,301	1,726,619	1,713,738
	2006	876,001	1,407,313	960,853	1,974,739	1,269,134	1,253,951
	2007	2,393,021	947,319	2,573,518	978,271	2,356,619	2,351,224
	2008	1,473,028	1,589,034	1,705,107	2,530,489	1,728,582	1,772,863
	2009	588,234	1,933,962	361,743	1,681,280	650,078	687,681
	2010	1,601,170	881,329	1,686,730	880,231	1,528,288	1,498,866
	mean	**1,361,053**	**1,362,905**	**1,368,160**	**1,390,962**	**1,370,843**	**1,374,707**
	std	**536,128**	**491,414**	**598,640**	**678,334**	**465,855**	**446,632**
26	***1997***	838,049	1,279,338	709,444	988,467	775,465	813,495
	1998	1,439,344	1,134,016	1,390,161	806,325	1,212,529	1,165,666
	1999	1,453,066	1,747,300	1,419,121	1,751,683	1,465,857	1,433,550
	2000	971,648	1,537,736	972,288	1,798,639	1,177,199	1,226,279
	2001	1,597,160	984,402	1,596,246	701,140	1,371,590	1,310,549
	2002	785,179	1,286,328	809,510	1,608,286	1,025,570	1,077,174
	2003	798,660	606,224	806,459	548,223	758,896	796,014
	2004	1,233,045	519,108	1,256,734	283,835	1,051,243	1,044,092
	2005	1,490,933	1,748,879	1,430,194	1,634,117	1,401,124	1,390,905
	2006	987,044	1,453,889	1,061,600	1,952,467	1,332,477	1,319,135
	2007	2,257,450	996,511	2,414,879	1,023,508	2,225,700	2,220,995
	2008	1,672,089	1,781,743	1,891,459	2,671,643	1,913,649	1,955,505
	2009	617,281	2,068,244	373,078	1,795,803	683,961	724,504
	2010	1,778,343	1,065,751	1,863,041	1,064,664	1,706,195	1,677,070
	mean	**1,279,949**	**1,300,676**	**1,285,301**	**1,330,628**	**1,292,961**	**1,296,781**
	std	**468,391**	**453,185**	**547,161**	**657,976**	**442,811**	**430,298**
27	***1997***	102,634	167,320	83,782	124,683	93,460	99,035
	1998	210,524	166,974	203,509	120,235	178,173	171,488
	1999	219,384	265,603	214,052	266,291	221,393	216,318
	2000	177,674	290,321	177,801	342,239	218,577	228,344
	2001	294,220	171,209	294,037	114,344	248,937	236,683
	2002	184,254	275,037	188,661	333,359	227,800	237,149

	2003	166,181	124,393	167,875	111,798	157,546	165,606
	2004	302,844	151,635	307,861	101,805	264,339	262,824
	2005	291,316	346,229	278,386	321,798	272,197	270,022
	2006	144,121	238,283	159,159	338,846	213,794	211,103
	2007	428,948	171,826	461,050	177,331	422,474	421,515
	2008	261,484	281,134	300,795	440,603	304,771	312,272
	2009	46,077	273,034	7,880	230,419	56,507	62,849
	2010	262,488	123,676	278,987	123,464	248,434	242,760
	mean	**220,868**	**217,620**	**223,131**	**224,801**	**223,457**	**224,141**
	std	**96,265**	**71,346**	**110,113**	**114,319**	**88,945**	**87,316**
28	***1997***	322,617	491,357	273,441	380,134	298,686	313,228
	1998	585,472	457,118	564,797	319,363	490,124	470,423
	1999	728,974	884,848	710,991	887,170	735,751	718,635
	2000	599,254	927,921	599,625	1,079,400	718,596	747,091
	2001	1,014,354	618,453	1,013,764	435,438	868,614	829,176
	2002	480,993	797,167	496,343	1,000,289	632,655	665,212
	2003	566,347	440,678	571,441	402,801	540,379	564,619
	2004	1,083,394	586,388	1,099,884	422,603	956,833	951,854
	2005	1,172,524	1,349,422	1,130,869	1,270,718	1,110,933	1,103,925
	2006	677,244	977,647	725,220	1,298,469	899,521	890,937
	2007	1,559,365	699,573	1,666,711	717,980	1,537,716	1,534,507
	2008	1,218,935	1,300,221	1,381,554	1,959,901	1,398,002	1,429,030
	2009	574,240	1,563,931	407,671	1,378,101	619,722	647,377
	2010	1,547,682	1,011,185	1,611,450	1,010,366	1,493,363	1,471,435
	mean	**866,528**	**864,708**	**875,269**	**897,338**	**878,635**	**881,246**
	std	**397,675**	**351,634**	**447,063**	**483,110**	**384,098**	**379,270**
29	***1997***	77,793	151,149	56,415	102,797	67,390	73,711
	1998	162,909	106,061	153,752	45,049	120,679	111,954
	1999	165,259	220,741	158,858	221,568	167,671	161,579
	2000	70,300	163,191	70,404	206,004	104,029	112,083
	2001	147,078	49,827	146,933	4,870	111,278	101,590
	2002	32,486	108,922	36,197	158,027	69,151	77,022
	2003	28,187	1,630	29,263	(6,374)	22,699	27,822
	2004	150,543	42,410	154,131	6,775	123,007	121,924
	2005	147,599	176,718	140,743	163,763	137,461	136,307
	2006	44,256	101,343	53,373	162,311	86,497	84,865
	2007	228,165	43,330	251,241	47,288	223,510	222,821
	2008	161,492	176,228	190,973	295,820	193,955	199,580
	2009	50,187	212,746	22,827	182,223	57,657	62,199

	2010	172,865	84,505	183,368	84,370	163,919	160,308
	mean	**117,080**	**117,057**	**117,748**	**119,606**	**117,779**	**118,126**
	std	**64,070**	**68,277**	**71,692**	**92,886**	**56,016**	**54,071**
30	***1997***	31,242	51,540	25,327	38,161	28,364	30,113
	1998	64,658	49,821	62,268	33,896	53,636	51,359
	1999	53,867	67,368	52,309	67,569	54,454	52,971
	2000	35,612	62,082	35,641	74,282	45,223	47,518
	2001	50,727	23,967	50,687	11,596	40,876	38,210
	2002	22,691	45,273	23,788	59,780	33,523	35,849
	2003	34,955	25,727	35,329	22,946	33,048	34,828
	2004	75,383	39,018	76,589	27,034	66,122	65,758
	2005	67,683	79,312	64,945	74,138	63,634	63,174
	2006	46,608	65,092	49,560	84,832	60,285	59,757
	2007	96,185	43,542	102,758	44,669	94,860	94,663
	2008	78,396	83,283	88,172	122,941	89,161	91,027
	2009	37,830	95,466	28,130	84,644	40,479	42,089
	2010	87,715	59,430	91,077	59,386	84,851	83,695
	mean	**55,968**	**56,494**	**56,184**	**57,563**	**56,323**	**56,501**
	std	**22,772**	**20,869**	**25,832**	**30,077**	**21,500**	**21,092**
31	***1997***	225,099	380,622	179,775	278,111	203,043	216,446
	1998	508,119	391,399	489,318	266,130	421,413	403,499
	1999	498,569	612,629	485,410	614,328	503,528	491,004
	2000	353,952	581,308	354,209	686,094	436,507	456,219
	2001	740,688	417,140	740,206	267,571	621,583	589,352
	2002	368,829	640,155	382,002	814,465	498,978	526,917
	2003	531,961	428,577	536,151	397,417	510,598	530,539
	2004	829,242	401,056	843,449	259,950	720,206	715,916
	2005	899,363	1,048,934	864,143	982,389	847,287	841,361
	2006	512,242	799,282	558,083	1,105,833	724,631	716,428
	2007	1,368,779	527,026	1,473,873	545,048	1,347,584	1,344,443
	2008	1,076,209	1,147,068	1,217,968	1,722,128	1,232,307	1,259,355
	2009	334,602	1,146,339	197,984	993,922	371,906	394,588
	2010	983,617	537,116	1,036,688	536,435	938,410	920,160
	mean	**659,377**	**647,046**	**668,518**	**676,416**	**669,856**	**671,873**
	std	**332,079**	**279,213**	**381,955**	**418,571**	**327,253**	**325,237**
32	***1997***	66,315	95,299	57,868	76,194	62,204	64,702
	1998	151,634	121,620	146,799	89,409	129,338	124,732
	1999	182,824	214,505	179,169	214,976	184,201	180,723
	2000	127,201	186,698	127,269	214,119	148,805	153,964

	2001	202,813	131,950	202,707	99,192	176,727	169,668
	2002	133,858	204,215	137,274	249,415	167,606	174,851
	2003	127,539	101,551	128,592	93,718	122,169	127,181
	2004	260,177	152,806	263,740	117,422	232,836	231,760
	2005	293,313	338,168	282,751	318,212	277,696	275,919
	2006	177,699	260,076	190,855	348,053	238,653	236,298
	2007	416,587	195,114	444,239	199,855	411,011	410,184
	2008	353,068	376,024	398,993	562,322	403,638	412,401
	2009	254,735	581,025	199,819	519,759	269,729	278,847
	2010	593,926	403,744	616,531	403,454	574,671	566,897
	mean	**238,692**	**240,200**	**241,186**	**250,436**	**242,806**	**243,438**
	std	**140,280**	**139,183**	**151,351**	**160,264**	**138,311**	**137,313**
33	***1997***	68,979	148,023	45,943	95,922	57,768	64,581
	1998	163,403	110,756	154,923	54,252	124,294	116,213
	1999	137,800	182,845	132,603	183,516	139,758	134,812
	2000	87,467	183,147	87,575	227,245	122,209	130,505
	2001	172,219	61,446	172,054	10,239	131,441	120,406
	2002	32,979	108,857	36,663	157,604	69,376	77,189
	2003	31,179	8,499	32,098	1,663	26,493	30,867
	2004	120,304	41,995	122,902	16,189	100,363	99,579
	2005	116,352	142,890	110,103	131,083	107,112	106,060
	2006	40,979	90,534	48,893	143,457	77,646	76,230
	2007	248,783	98,597	267,534	101,813	245,002	244,441
	2008	138,099	151,248	164,404	257,955	167,065	172,084
	2009	26,086	180,373	118	151,403	33,176	37,487
	2010	156,660	85,923	165,068	85,815	149,498	146,607
	mean	**110,092**	**113,938**	**110,063**	**115,583**	**110,800**	**111,219**
	std	**65,639**	**54,063**	**72,968**	**78,739**	**57,602**	**55,716**
34	***1997***	149,064	220,109	128,359	173,280	138,988	145,111
	1998	331,277	266,530	320,848	197,041	283,180	273,242
	1999	407,184	488,953	397,751	490,171	410,739	401,761
	2000	327,264	493,724	327,452	570,443	387,707	402,139
	2001	499,791	319,261	499,522	235,806	433,334	415,350
	2002	255,769	413,209	263,413	514,355	331,290	347,502
	2003	316,909	249,162	319,654	228,743	302,910	315,977
	2004	1,079,270	608,139	1,094,902	452,882	959,298	954,579
	2005	956,643	1,110,248	920,474	1,041,908	903,163	897,078
	2006	524,025	792,129	566,842	1,078,457	722,403	714,742
	2007	1,424,662	651,032	1,521,250	667,595	1,405,182	1,402,295

	2008	1,038,870	1,108,185	1,177,539	1,670,710	1,191,565	1,218,024
	2009	550,665	1,361,942	414,123	1,209,611	587,947	610,617
	2010	1,163,975	737,002	1,214,724	736,350	1,120,745	1,103,293
	mean	**644,669**	**629,973**	**654,775**	**661,954**	**655,604**	**657,265**
	std	**404,180**	**357,435**	**440,188**	**444,498**	**396,555**	**395,255**
35	***1997***	541,365	835,602	455,616	641,659	499,636	524,994
	1998	1,108,030	864,401	1,068,786	602,928	927,049	889,656
	1999	1,106,182	1,344,681	1,078,667	1,348,233	1,116,550	1,090,363
	2000	775,043	1,232,809	775,560	1,443,788	941,261	980,950
	2001	1,498,203	881,248	1,497,283	596,046	1,271,088	1,209,629
	2002	647,725	1,152,167	672,216	1,476,241	889,695	941,639
	2003	735,122	551,145	742,579	495,693	697,106	732,592
	2004	1,401,867	678,230	1,425,877	439,761	1,217,595	1,210,347
	2005	1,339,274	1,581,089	1,282,334	1,473,504	1,255,082	1,245,502
	2006	752,034	1,180,054	820,390	1,637,167	1,068,739	1,056,507
	2007	1,825,643	651,700	1,972,210	676,834	1,796,083	1,791,702
	2008	1,529,494	1,626,637	1,723,834	2,414,996	1,743,492	1,780,572
	2009	754,322	1,867,200	567,020	1,658,239	805,465	836,562
	2010	1,507,954	875,764	1,583,096	874,799	1,443,947	1,418,107
	mean	**1,108,733**	**1,094,481**	**1,118,962**	**1,127,135**	**1,119,485**	**1,122,080**
	std	**409,442**	**400,697**	**469,899**	**589,783**	**370,950**	**361,818**
36	***1997***	178,772	257,831	155,732	205,720	167,560	174,373
	1998	281,145	218,686	271,084	151,652	234,747	225,160
	1999	360,587	431,820	352,369	432,881	363,684	355,862
	2000	246,093	379,495	246,244	440,978	294,532	306,098
	2001	368,955	220,936	368,735	152,510	314,466	299,721
	2002	279,021	412,662	285,509	498,518	343,126	356,887
	2003	220,849	167,046	223,029	150,830	209,731	220,109
	2004	435,809	229,181	442,665	161,089	383,192	381,122
	2005	500,458	565,290	485,191	536,446	477,885	475,316
	2006	315,004	437,341	334,542	567,993	405,525	402,029
	2007	639,236	308,322	680,551	315,406	630,904	629,669
	2008	494,445	525,251	556,075	775,261	562,309	574,068
	2009	193,674	571,034	130,163	500,178	211,016	221,560
	2010	461,019	272,123	483,471	271,835	441,894	434,173
	mean	**355,362**	**356,930**	**358,240**	**368,664**	**360,041**	**361,153**
	std	**135,634**	**136,617**	**156,745**	**196,084**	**136,350**	**135,158**

7. Net farm profit per cwt. of milk of 36 sample farms

sample farm	*year*	*no hedge*	*short milk*	*long corn*	*short milk and long corn*	*short R1*	*short R2*
1	***1997***	3.144	5.059	2.585	3.796	2.872	3.037
	1998	6.227	4.882	6.010	3.438	5.228	5.021
	1999	5.555	6.798	5.411	6.816	5.609	5.472
	2000	3.904	6.193	3.907	7.248	4.735	4.934
	2001	5.536	2.935	5.532	1.732	4.579	4.320
	2002	2.344	4.443	2.446	5.791	3.351	3.567
	2003	2.510	1.711	2.542	1.470	2.345	2.499
	2004	5.952	2.827	6.056	1.798	5.156	5.125
	2005	5.819	6.826	5.582	6.378	5.468	5.428
	2006	3.595	5.340	3.873	7.203	4.886	4.836
	2007	8.627	3.722	9.239	3.827	8.503	8.485
	2008	5.536	5.952	6.369	9.332	6.453	6.612
	2009	1.437	6.376	0.606	5.449	1.664	1.802
	2010	5.071	2.592	5.365	2.589	4.820	4.718
	mean	**4.661**	**4.690**	**4.680**	**4.776**	**4.691**	**4.704**
	std	**1.923**	**1.690**	**2.178**	**2.457**	**1.742**	**1.685**
2	***1997***	4.350	6.265	3.792	5.003	4.078	4.243
	1998	6.293	4.948	6.077	3.504	5.294	5.088
	1999	6.251	7.494	6.108	7.513	6.305	6.169
	2000	4.381	6.669	4.383	7.724	5.212	5.410
	2001	6.663	4.061	6.659	2.859	5.705	5.446
	2002	3.160	5.259	3.262	6.608	4.167	4.383
	2003	3.446	2.647	3.478	2.407	3.281	3.435
	2004	6.318	3.194	6.422	2.164	5.523	5.491
	2005	5.905	6.913	5.668	6.465	5.555	5.515
	2006	3.711	5.456	3.990	7.319	5.002	4.952
	2007	9.663	4.758	10.275	4.863	9.540	9.521
	2008	6.602	7.018	7.435	10.398	7.519	7.678
	2009	1.663	6.603	0.832	5.675	1.890	2.028
	2010	6.527	4.049	6.822	4.045	6.276	6.175
	mean	**5.352**	**5.381**	**5.372**	**5.468**	**5.382**	**5.395**

	std	**2.017**	**1.514**	**2.292**	**2.368**	**1.832**	**1.782**
3	***1997***	0.252	2.168	(0.306)	0.905	(0.019)	0.146
	1998	2.466	1.121	2.249	(0.323)	1.467	1.260
	1999	2.744	3.987	2.600	4.005	2.798	2.661
	2000	0.143	2.432	0.146	3.487	0.974	1.173
	2001	2.405	(0.196)	2.401	(1.399)	1.448	1.188
	2002	(1.077)	1.022	(0.975)	2.370	(0.070)	0.146
	2003	(0.642)	(1.440)	(0.609)	(1.681)	(0.807)	(0.653)
	2004	2.871	(0.254)	2.975	(1.283)	2.075	2.044
	2005	2.458	3.465	2.221	3.017	2.107	2.067
	2006	(0.306)	1.438	(0.028)	3.302	0.985	0.935
	2007	5.116	0.211	5.728	0.316	4.992	4.974
	2008	2.184	2.601	3.018	5.980	3.102	3.261
	2009	(1.774)	3.165	(2.606)	2.238	(1.547)	(1.409)
	2010	1.700	(0.779)	1.994	(0.783)	1.449	1.347
	mean	**1.324**	**1.353**	**1.343**	**1.439**	**1.354**	**1.367**
	std	**1.919**	**1.684**	**2.152**	**2.380**	**1.682**	**1.623**
4	***1997***	3.871	5.787	3.313	4.524	3.600	3.765
	1998	6.685	5.340	6.468	3.896	5.686	5.479
	1999	6.663	7.906	6.519	7.924	6.717	6.580
	2000	4.852	7.141	4.855	8.196	5.683	5.882
	2001	7.264	4.663	7.260	3.460	6.307	6.048
	2002	4.572	6.671	4.674	8.019	5.579	5.795
	2003	4.437	3.639	4.470	3.398	4.272	4.427
	2004	7.970	4.845	8.074	3.816	7.174	7.143
	2005	7.477	8.484	7.240	8.036	7.126	7.086
	2006	4.883	6.628	5.161	8.491	6.174	6.124
	2007	9.885	4.980	10.497	5.085	9.761	9.743
	2008	6.724	7.140	7.557	10.519	7.641	7.800
	2009	2.915	7.854	2.084	6.927	3.142	3.280
	2010	6.379	3.900	6.673	3.896	6.128	6.026
	mean	**6.041**	**6.070**	**6.060**	**6.156**	**6.071**	**6.084**
	std	**1.869**	**1.550**	**2.142**	**2.382**	**1.695**	**1.645**
5	***1997***	3.217	5.133	2.659	3.870	2.946	3.111
	1998	5.301	3.956	5.084	2.512	4.302	4.095
	1999	5.909	7.152	5.765	7.170	5.963	5.826
	2000	3.618	5.907	3.621	6.962	4.449	4.648
	2001	6.260	3.659	6.256	2.456	5.303	5.044
	2002	3.418	5.517	3.520	6.865	4.425	4.641
	2003	3.393	2.595	3.426	2.354	3.228	3.383

	2004	5.986	2.861	6.090	1.832	5.190	5.159
	2005	5.723	6.730	5.486	6.282	5.372	5.332
	2006	4.029	5.774	4.307	7.637	5.320	5.270
	2007	9.411	4.506	10.023	4.611	9.287	9.269
	2008	6.470	6.886	7.303	10.265	7.387	7.546
	2009	1.871	6.810	1.040	5.883	2.098	2.236
	2010	5.605	3.126	5.899	3.122	5.354	5.252
	mean	**5.015**	**5.044**	**5.034**	**5.130**	**5.045**	**5.058**
	std	**1.899**	**1.597**	**2.204**	**2.535**	**1.805**	**1.765**
6	***1997***	3.704	5.620	3.146	4.357	3.432	3.597
	1998	6.517	5.172	6.301	3.729	5.518	5.312
	1999	5.545	6.788	5.402	6.807	5.599	5.463
	2000	3.975	6.263	3.977	7.318	4.806	5.004
	2001	6.677	4.075	6.673	2.873	5.719	5.460
	2002	3.225	5.324	3.327	6.672	4.231	4.448
	2003	3.550	2.752	3.582	2.511	3.385	3.539
	2004	6.962	3.838	7.066	2.808	6.167	6.136
	2005	6.239	7.247	6.002	6.799	5.889	5.849
	2006	3.645	5.390	3.924	7.254	4.936	4.886
	2007	8.657	3.752	9.270	3.857	8.534	8.515
	2008	5.956	6.373	6.789	9.752	6.873	7.032
	2009	1.547	6.487	0.716	5.559	1.774	1.912
	2010	5.381	2.903	5.676	2.899	5.130	5.029
	mean	**5.113**	**5.142**	**5.132**	**5.228**	**5.142**	**5.156**
	std	**1.897**	**1.456**	**2.155**	**2.239**	**1.644**	**1.584**
7	***1997***	3.727	5.642	3.168	4.380	3.455	3.620
	1998	6.350	5.005	6.133	3.561	5.351	5.144
	1999	6.008	7.251	5.865	7.270	6.062	5.926
	2000	4.567	6.856	4.570	7.911	5.398	5.597
	2001	7.170	4.568	7.166	3.365	6.212	5.953
	2002	3.467	5.566	3.569	6.915	4.474	4.690
	2003	3.833	3.034	3.865	2.794	3.668	3.822
	2004	6.765	3.641	6.869	2.611	5.969	5.938
	2005	6.362	7.370	6.125	6.921	6.011	5.971
	2006	3.558	5.303	3.837	7.166	4.849	4.799
	2007	9.130	4.225	9.742	4.330	9.006	8.988
	2008	6.309	6.725	7.142	10.105	7.226	7.385
	2009	2.300	7.239	1.469	6.312	2.527	2.665
	2010	6.124	3.645	6.418	3.642	5.873	5.772

	mean	**5.405**	**5.434**	**5.424**	**5.520**	**5.434**	**5.448**
	std	**1.863**	**1.484**	**2.126**	**2.281**	**1.630**	**1.574**
8	***1997***	3.696	5.611	3.138	4.349	3.424	3.589
	1998	6.049	4.704	5.833	3.260	5.050	4.844
	1999	5.987	7.230	5.844	7.249	6.041	5.905
	2000	4.177	6.465	4.179	7.520	5.008	5.206
	2001	6.469	3.867	6.465	2.665	5.511	5.252
	2002	3.196	5.295	3.298	6.644	4.203	4.419
	2003	3.892	3.093	3.924	2.853	3.727	3.881
	2004	7.414	4.290	7.518	3.260	6.619	6.587
	2005	6.951	7.959	6.714	7.511	6.601	6.561
	2006	3.817	5.562	4.096	7.425	5.108	5.058
	2007	9.099	4.194	9.711	4.299	8.976	8.957
	2008	6.038	6.454	6.871	9.834	6.955	7.114
	2009	1.749	6.689	0.918	5.761	1.976	2.114
	2010	5.603	3.125	5.898	3.121	5.352	5.251
	mean	**5.296**	**5.324**	**5.315**	**5.411**	**5.325**	**5.339**
	std	**1.956**	**1.515**	**2.212**	**2.295**	**1.725**	**1.673**
9	***1997***	4.694	6.609	4.135	5.347	4.422	4.587
	1998	6.197	4.852	5.980	3.408	5.198	4.991
	1999	6.465	7.708	6.322	7.727	6.519	6.383
	2000	4.314	6.603	4.317	7.658	5.145	5.344
	2001	7.407	4.805	7.403	3.602	6.449	6.190
	2002	3.504	5.603	3.606	6.952	4.511	4.727
	2003	3.600	2.801	3.632	2.561	3.435	3.589
	2004	6.282	3.158	6.386	2.128	5.486	5.455
	2005	5.919	6.927	5.682	6.478	5.568	5.528
	2006	5.025	6.770	5.304	8.633	6.316	6.266
	2007	8.627	3.722	9.239	3.827	8.503	8.485
	2008	5.696	6.112	6.529	9.492	6.613	6.772
	2009	1.917	6.856	1.086	5.929	2.144	2.282
	2010	5.421	2.942	5.715	2.939	5.170	5.069
	mean	**5.362**	**5.391**	**5.381**	**5.477**	**5.391**	**5.405**
	std	**1.712**	**1.673**	**1.963**	**2.418**	**1.537**	**1.472**
10	***1997***	(5.297)	(3.381)	(5.855)	(4.644)	(5.569)	(5.403)
	1998	(2.563)	(3.909)	(2.780)	(5.352)	(3.563)	(3.769)
	1999	(2.986)	(1.742)	(3.129)	(1.724)	(2.932)	(3.068)
	2000	(5.376)	(3.087)	(5.374)	(2.033)	(4.545)	(4.347)
	2001	(2.294)	(4.895)	(2.298)	(6.098)	(3.252)	(3.511)

	2002	(5.256)	(3.157)	(5.154)	(1.809)	(4.249)	(4.033)
	2003	(6.761)	(7.559)	(6.728)	(7.800)	(6.926)	(6.772)
	2004	(1.918)	(5.043)	(1.815)	(6.073)	(2.714)	(2.745)
	2005	(2.771)	(1.764)	(3.009)	(2.212)	(3.122)	(3.162)
	2006	(5.786)	(4.041)	(5.507)	(2.177)	(4.495)	(4.544)
	2007	(0.814)	(5.719)	(0.201)	(5.614)	(0.937)	(0.955)
	2008	(5.065)	(4.648)	(4.232)	(1.269)	(4.147)	(3.988)
	2009	(7.843)	(2.904)	(8.675)	(3.832)	(7.616)	(7.478)
	2010	(4.410)	(6.888)	(4.115)	(6.892)	(4.661)	(4.762)
	mean	**(4.224)**	**(4.196)**	**(4.205)**	**(4.109)**	**(4.195)**	**(4.181)**
	std	**2.025**	**1.731**	**2.202**	**2.219**	**1.717**	**1.641**
11	***1997***	(0.055)	1.860	(0.614)	0.598	(0.327)	(0.162)
	1998	2.228	0.883	2.011	(0.561)	1.229	1.022
	1999	2.116	3.359	1.973	3.378	2.170	2.033
	2000	0.065	2.354	0.068	3.409	0.896	1.095
	2001	2.287	(0.314)	2.284	(1.517)	1.330	1.071
	2002	(0.465)	1.634	(0.363)	2.983	0.542	0.758
	2003	(0.869)	(1.668)	(0.837)	(1.909)	(1.034)	(0.880)
	2004	2.273	(0.851)	2.377	(1.881)	1.477	1.446
	2005	2.280	3.288	2.043	2.839	1.929	1.889
	2006	(0.364)	1.381	(0.086)	3.244	0.927	0.877
	2007	5.048	0.143	5.660	0.248	4.924	4.906
	2008	2.287	2.703	3.120	6.083	3.204	3.363
	2009	(2.602)	2.337	(3.433)	1.410	(2.375)	(2.237)
	2010	0.422	(2.057)	0.716	(2.060)	0.171	0.070
	mean	**1.046**	**1.075**	**1.066**	**1.162**	**1.076**	**1.089**
	std	**1.931**	**1.774**	**2.190**	**2.558**	**1.776**	**1.734**
12	***1997***	3.224	5.140	2.666	3.877	2.953	3.118
	1998	5.628	4.283	5.411	2.839	4.628	4.422
	1999	5.216	6.459	5.072	6.477	5.270	5.133
	2000	3.005	5.294	3.008	6.349	3.836	4.034
	2001	5.757	3.156	5.753	1.953	4.800	4.540
	2002	2.095	4.194	2.197	5.542	3.102	3.318
	2003	2.970	2.172	3.003	1.931	2.805	2.959
	2004	5.513	2.388	5.616	1.359	4.717	4.686
	2005	5.890	6.897	5.653	6.449	5.539	5.499
	2006	2.316	4.060	2.594	5.924	3.607	3.557
	2007	8.658	3.753	9.270	3.858	8.534	8.516
	2008	6.456	6.873	7.289	10.252	7.374	7.533

	2009	2.848	7.787	2.016	6.860	3.075	3.213
	2010	6.962	4.483	7.256	4.479	6.711	6.609
	mean	**4.753**	**4.781**	**4.772**	**4.868**	**4.782**	**4.795**
	std	**2.002**	**1.722**	**2.242**	**2.442**	**1.768**	**1.719**
13	***1997***	3.592	5.508	3.034	4.245	3.321	3.486
	1998	5.706	4.360	5.489	2.917	4.706	4.500
	1999	5.524	6.767	5.380	6.785	5.578	5.441
	2000	3.513	5.802	3.516	6.857	4.344	4.542
	2001	6.065	3.464	6.061	2.261	5.107	4.848
	2002	2.413	4.512	2.515	5.860	3.420	3.636
	2003	3.038	2.240	3.071	1.999	2.873	3.027
	2004	6.631	3.506	6.734	2.477	5.835	5.804
	2005	6.208	7.215	5.970	6.767	5.857	5.817
	2006	3.543	5.288	3.822	7.152	4.835	4.785
	2007	9.255	4.351	9.868	4.456	9.132	9.114
	2008	6.744	7.161	7.577	10.540	7.662	7.821
	2009	2.826	7.765	1.994	6.838	3.053	3.191
	2010	6.909	4.431	7.204	4.427	6.659	6.557
	mean	**5.141**	**5.169**	**5.160**	**5.256**	**5.170**	**5.183**
	std	**2.002**	**1.630**	**2.265**	**2.429**	**1.807**	**1.758**
14	***1997***	1.854	3.770	1.296	2.507	1.583	1.748
	1998	5.588	4.243	5.371	2.799	4.589	4.382
	1999	3.986	5.229	3.842	5.247	4.040	3.903
	2000	2.125	4.414	2.128	5.469	2.956	3.155
	2001	4.287	1.686	4.283	0.483	3.330	3.070
	2002	1.265	3.364	1.367	4.712	2.272	2.488
	2003	1.770	0.972	1.803	0.731	1.605	1.759
	2004	4.993	1.868	5.097	0.839	4.197	4.166
	2005	4.680	5.687	4.443	5.239	4.329	4.289
	2006	2.026	3.770	2.304	5.634	3.317	3.267
	2007	7.148	2.243	7.760	2.348	7.024	7.006
	2008	4.326	4.743	5.160	8.122	5.244	5.403
	2009	1.268	6.207	0.437	5.280	1.495	1.633
	2010	5.002	2.523	5.296	2.519	4.751	4.649
	mean	**3.594**	**3.623**	**3.613**	**3.709**	**3.624**	**3.637**
	std	**1.854**	**1.590**	**2.087**	**2.279**	**1.584**	**1.518**
15	***1997***	3.090	5.005	2.531	3.743	2.818	2.983
	1998	5.263	3.918	5.046	2.474	4.264	4.057
	1999	4.921	6.164	4.778	6.183	4.975	4.839

	2000	2.930	5.219	2.933	6.274	3.761	3.960
	2001	5.283	2.681	5.279	1.478	4.325	4.066
	2002	2.240	4.339	2.342	5.688	3.247	3.463
	2003	2.526	1.727	2.558	1.487	2.361	2.515
	2004	5.598	2.474	5.702	1.444	4.803	4.771
	2005	4.895	5.903	4.658	5.454	4.544	4.504
	2006	2.911	4.656	3.190	6.519	4.202	4.152
	2007	7.873	2.968	8.485	3.073	7.749	7.731
	2008	5.052	5.468	5.885	8.848	5.969	6.128
	2009	0.993	5.932	0.162	5.005	1.220	1.358
	2010	5.497	3.018	5.791	3.015	5.246	5.145
	mean	**4.219**	**4.248**	**4.239**	**4.335**	**4.249**	**4.262**
	std	**1.810**	**1.458**	**2.080**	**2.281**	**1.597**	**1.541**
16	***1997***	2.308	4.223	1.749	2.961	2.036	2.201
	1998	4.561	3.216	4.344	1.772	3.562	3.355
	1999	4.699	5.942	4.556	5.961	4.753	4.617
	2000	3.088	5.377	3.091	6.432	3.919	4.118
	2001	5.001	2.399	4.997	1.197	4.043	3.784
	2002	1.968	4.067	2.070	5.416	2.975	3.191
	2003	2.224	1.425	2.256	1.185	2.059	2.213
	2004	5.346	2.222	5.450	1.192	4.551	4.519
	2005	5.113	6.121	4.876	5.672	4.762	4.722
	2006	2.509	4.254	2.788	6.117	3.800	3.750
	2007	8.451	3.546	9.063	3.651	8.327	8.309
	2008	5.450	5.866	6.283	9.246	6.367	6.526
	2009	0.591	5.530	(0.240)	4.603	0.818	0.956
	2010	4.705	2.227	5.000	2.223	4.454	4.353
	mean	**4.001**	**4.030**	**4.020**	**4.116**	**4.030**	**4.044**
	std	**2.002**	**1.579**	**2.291**	**2.476**	**1.861**	**1.821**
17	***1997***	3.315	5.230	2.756	3.968	3.043	3.208
	1998	5.648	4.303	5.431	2.859	4.649	4.442
	1999	5.616	6.859	5.473	6.878	5.670	5.533
	2000	3.555	5.844	3.558	6.899	4.386	4.585
	2001	5.467	2.866	5.464	1.663	4.510	4.251
	2002	2.445	4.544	2.547	5.893	3.452	3.668
	2003	2.751	1.952	2.783	1.711	2.586	2.740
	2004	5.633	2.509	5.737	1.479	4.837	4.806
	2005	5.340	6.348	5.103	5.899	4.989	4.949
	2006	2.836	4.581	3.114	6.444	4.127	4.077

	2007	8.608	3.703	9.220	3.808	8.484	8.466
	2008	4.807	5.223	5.640	8.603	5.724	5.883
	2009	0.818	5.757	(0.013)	4.830	1.045	1.183
	2010	4.942	2.463	5.236	2.460	4.691	4.590
	mean	**4.413**	**4.442**	**4.432**	**4.528**	**4.442**	**4.456**
	std	**1.931**	**1.552**	**2.178**	**2.297**	**1.712**	**1.657**
18	***1997***	3.720	5.635	3.161	4.373	3.448	3.613
	1998	6.483	5.138	6.266	3.694	5.484	5.277
	1999	6.141	7.384	5.998	7.403	6.195	6.059
	2000	4.650	6.939	4.653	7.994	5.481	5.680
	2001	6.802	4.201	6.799	2.998	5.845	5.586
	2002	2.930	5.029	3.032	6.378	3.937	4.153
	2003	3.636	2.837	3.668	2.597	3.471	3.625
	2004	7.468	4.344	7.572	3.314	6.672	6.641
	2005	6.675	7.683	6.438	7.234	6.324	6.284
	2006	4.361	6.106	4.640	7.969	5.652	5.602
	2007	10.203	5.298	10.815	5.403	10.079	10.061
	2008	7.142	7.558	7.975	10.938	8.059	8.218
	2009	2.953	7.892	2.122	6.965	3.180	3.318
	2010	7.017	4.538	7.311	4.535	6.766	6.665
	mean	**5.727**	**5.756**	**5.746**	**5.842**	**5.757**	**5.770**
	std	**2.084**	**1.550**	**2.358**	**2.398**	**1.902**	**1.850**
19	***1997***	4.104	6.020	3.546	4.757	3.833	3.998
	1998	7.108	5.762	6.891	4.319	6.108	5.902
	1999	6.596	7.839	6.452	7.857	6.650	6.513
	2000	4.595	6.884	4.598	7.939	5.426	5.624
	2001	6.737	4.136	6.733	2.933	5.779	5.520
	2002	3.255	5.354	3.357	6.702	4.262	4.478
	2003	3.390	2.592	3.423	2.351	3.225	3.379
	2004	6.783	3.658	6.886	2.629	5.987	5.956
	2005	6.260	7.267	6.022	6.819	5.909	5.869
	2006	3.975	5.720	4.254	7.584	5.267	5.217
	2007	9.667	4.763	10.280	4.868	9.544	9.526
	2008	6.616	7.033	7.449	10.412	7.534	7.693
	2009	2.348	7.287	1.516	6.360	2.575	2.713
	2010	6.641	4.163	6.936	4.159	6.391	6.289
	mean	**5.577**	**5.606**	**5.596**	**5.692**	**5.606**	**5.620**
	std	**1.998**	**1.577**	**2.255**	**2.358**	**1.785**	**1.724**
20	***1997***	3.876	5.792	3.318	4.529	3.604	3.769

	1998	6.199	4.854	5.983	3.410	5.200	4.994
	1999	6.067	7.310	5.924	7.329	6.121	5.985
	2000	4.257	6.545	4.259	7.600	5.088	5.286
	2001	6.549	3.947	6.545	2.745	5.591	5.332
	2002	2.947	5.045	3.048	6.394	3.953	4.169
	2003	3.482	2.683	3.514	2.443	3.317	3.471
	2004	6.454	3.330	6.558	2.300	5.659	5.627
	2005	5.801	6.809	5.564	6.361	5.451	5.411
	2006	3.227	4.972	3.506	6.835	4.518	4.468
	2007	9.519	4.614	10.132	4.719	9.396	9.377
	2008	6.528	6.944	7.361	10.324	7.445	7.604
	2009	2.329	7.269	1.498	6.341	2.556	2.694
	2010	6.473	3.995	6.768	3.991	6.222	6.121
	mean	**5.265**	**5.294**	**5.284**	**5.380**	**5.294**	**5.308**
	std	**1.967**	**1.514**	**2.232**	**2.324**	**1.753**	**1.704**
21	***1997***	4.991	6.907	4.433	5.644	4.720	4.885
	1998	7.555	6.210	7.338	4.766	6.556	6.349
	1999	7.683	8.926	7.539	8.944	7.737	7.600
	2000	5.872	8.161	5.875	9.216	6.703	6.902
	2001	7.804	5.203	7.800	4.000	6.847	6.588
	2002	4.872	6.971	4.974	8.319	5.879	6.095
	2003	4.698	3.899	4.730	3.658	4.533	4.687
	2004	7.790	4.665	7.894	3.636	6.994	6.963
	2005	7.397	8.404	7.160	7.956	7.046	7.006
	2006	4.803	6.548	5.081	8.411	6.094	6.044
	2007	9.915	5.010	10.527	5.115	9.791	9.773
	2008	7.804	8.220	8.637	11.599	8.721	8.880
	2009	3.615	8.554	2.784	7.627	3.842	3.980
	2010	7.249	4.770	7.543	4.767	6.998	6.896
	mean	**6.575**	**6.603**	**6.594**	**6.690**	**6.604**	**6.618**
	std	**1.761**	**1.682**	**2.030**	**2.487**	**1.587**	**1.540**
22	***1997***	1.724	3.640	1.166	2.377	1.452	1.618
	1998	3.878	2.532	3.661	1.089	2.878	2.672
	1999	3.955	5.199	3.812	5.217	4.010	3.873
	2000	2.475	4.764	2.477	5.819	3.306	3.504
	2001	5.077	2.476	5.073	1.273	4.119	3.860
	2002	1.465	3.564	1.567	4.912	2.472	2.688
	2003	1.350	0.552	1.383	0.311	1.185	1.339
	2004	3.863	0.738	3.966	(0.292)	3.067	3.036

	2005	2.880	3.887	2.642	3.439	2.529	2.489
	2006	1.615	3.360	1.894	5.224	2.906	2.857
	2007	7.187	2.283	7.800	2.388	7.064	7.046
	2008	4.426	4.843	5.259	8.222	5.344	5.503
	2009	0.388	5.327	(0.444)	4.399	0.615	0.753
	2010	3.991	1.513	4.286	1.509	3.740	3.639
	mean	**3.162**	**3.191**	**3.182**	**3.278**	**3.192**	**3.205**
	std	**1.812**	**1.574**	**2.097**	**2.441**	**1.671**	**1.627**
23	***1997***	3.081	4.996	2.522	3.734	2.809	2.974
	1998	5.124	3.779	4.907	2.335	4.125	3.918
	1999	5.302	6.545	5.158	6.564	5.356	5.219
	2000	3.201	5.490	3.204	6.545	4.032	4.231
	2001	5.603	3.002	5.600	1.799	4.646	4.387
	2002	2.691	4.790	2.793	6.139	3.698	3.914
	2003	3.117	2.318	3.149	2.077	2.952	3.106
	2004	6.429	3.305	6.533	2.275	5.633	5.602
	2005	6.086	7.093	5.849	6.645	5.735	5.695
	2006	3.672	5.417	3.950	7.280	4.963	4.913
	2007	8.824	3.919	9.436	4.024	8.700	8.682
	2008	6.053	6.469	6.886	9.849	6.970	7.129
	2009	1.574	6.513	0.743	5.586	1.801	1.939
	2010	5.328	2.849	5.622	2.846	5.077	4.976
	mean	**4.720**	**4.749**	**4.739**	**4.835**	**4.750**	**4.763**
	std	**1.916**	**1.572**	**2.202**	**2.450**	**1.766**	**1.723**
24	***1997***	4.141	6.057	3.583	4.794	3.869	4.034
	1998	5.964	4.619	5.748	3.176	4.965	4.759
	1999	5.672	6.915	5.529	6.934	5.726	5.590
	2000	3.812	6.100	3.814	7.155	4.643	4.841
	2001	3.894	1.292	3.890	0.090	2.936	2.677
	2002	2.872	4.971	2.973	6.319	3.878	4.095
	2003	3.807	3.009	3.839	2.768	3.642	3.796
	2004	6.009	2.885	6.113	1.855	5.214	5.183
	2005	5.496	6.504	5.259	6.056	5.146	5.106
	2006	3.002	4.747	3.281	6.611	4.293	4.243
	2007	8.814	3.909	9.427	4.014	8.691	8.672
	2008	6.243	6.659	7.076	10.039	7.160	7.319
	2009	2.654	7.594	1.823	6.666	2.881	3.019
	2010	6.408	3.930	6.703	3.926	6.157	6.056
	mean	**4.914**	**4.942**	**4.933**	**5.029**	**4.943**	**4.956**

	std	**1.742**	**1.806**	**2.001**	**2.579**	**1.616**	**1.606**
25	***1997***	3.036	4.951	2.477	3.689	2.764	2.929
	1998	6.329	4.984	6.112	3.540	5.330	5.123
	1999	6.387	7.630	6.244	7.649	6.441	6.304
	2000	3.676	5.965	3.679	7.020	4.507	4.706
	2001	6.058	3.457	6.055	2.254	5.101	4.842
	2002	2.646	4.745	2.748	6.094	3.653	3.869
	2003	2.842	2.043	2.874	1.802	2.677	2.831
	2004	5.894	2.770	5.998	1.740	5.098	5.067
	2005	5.701	6.709	5.464	6.260	5.350	5.310
	2006	2.877	4.622	3.155	6.485	4.168	4.118
	2007	8.119	3.214	8.731	3.319	7.995	7.977
	2008	5.288	5.704	6.121	9.084	6.205	6.364
	2009	2.159	7.098	1.328	6.171	2.386	2.524
	2010	5.513	3.034	5.807	3.031	5.262	5.161
	mean	**4.752**	**4.780**	**4.771**	**4.867**	**4.781**	**4.795**
	std	**1.833**	**1.718**	**2.053**	**2.367**	**1.572**	**1.501**
26	***1997***	3.638	5.553	3.080	4.291	3.366	3.531
	1998	6.341	4.996	6.125	3.552	5.342	5.136
	1999	6.139	7.382	5.996	7.401	6.193	6.057
	2000	3.929	6.217	3.931	7.272	4.760	4.958
	2001	6.781	4.179	6.777	2.977	5.823	5.564
	2002	3.288	5.387	3.390	6.736	4.295	4.511
	2003	3.314	2.515	3.346	2.275	3.149	3.303
	2004	5.396	2.272	5.500	1.242	4.601	4.569
	2005	5.823	6.831	5.586	6.383	5.473	5.433
	2006	3.689	5.434	3.968	7.297	4.980	4.930
	2007	8.781	3.876	9.393	3.981	8.658	8.639
	2008	6.350	6.766	7.183	10.146	7.267	7.426
	2009	2.101	7.041	1.270	6.113	2.328	2.466
	2010	6.185	3.707	6.480	3.703	5.934	5.833
	mean	**5.125**	**5.154**	**5.145**	**5.241**	**5.155**	**5.168**
	std	**1.825**	**1.649**	**2.096**	**2.465**	**1.651**	**1.592**
27	***1997***	3.039	4.955	2.481	3.692	2.768	2.933
	1998	6.503	5.158	6.286	3.714	5.503	5.297
	1999	5.901	7.144	5.757	7.162	5.955	5.818
	2000	3.610	5.899	3.613	6.954	4.441	4.640
	2001	6.222	3.621	6.218	2.418	5.265	5.005
	2002	4.260	6.359	4.362	7.707	5.267	5.483

	2003	3.175	2.377	3.208	2.136	3.010	3.164
	2004	6.258	3.133	6.362	2.104	5.462	5.431
	2005	5.345	6.352	5.108	5.904	4.994	4.954
	2006	2.671	4.415	2.949	6.279	3.962	3.912
	2007	8.183	3.278	8.795	3.383	8.059	8.041
	2008	5.541	5.958	6.375	9.337	6.459	6.618
	2009	1.003	5.942	0.171	5.015	1.230	1.368
	2010	4.687	2.208	4.981	2.204	4.436	4.334
	mean	**4.743**	**4.771**	**4.762**	**4.858**	**4.772**	**4.786**
	std	**1.900**	**1.606**	**2.157**	**2.384**	**1.690**	**1.641**
28	***1997***	3.662	5.578	3.104	4.315	3.391	3.556
	1998	6.136	4.791	5.919	3.347	5.137	4.930
	1999	5.814	7.057	5.670	7.075	5.868	5.731
	2000	4.173	6.462	4.176	7.517	5.004	5.203
	2001	6.665	4.064	6.661	2.861	5.708	5.449
	2002	3.193	5.292	3.295	6.640	4.200	4.416
	2003	3.599	2.800	3.631	2.559	3.434	3.588
	2004	6.811	3.686	6.915	2.657	6.015	5.984
	2005	6.678	7.685	6.441	7.237	6.327	6.287
	2006	3.934	5.679	4.212	7.542	5.225	5.175
	2007	8.896	3.991	9.508	4.096	8.772	8.754
	2008	6.245	6.661	7.078	10.040	7.162	7.321
	2009	2.866	7.805	2.035	6.878	3.093	3.231
	2010	7.150	4.671	7.444	4.667	6.899	6.797
	mean	**5.416**	**5.444**	**5.435**	**5.531**	**5.445**	**5.459**
	std	**1.822**	**1.543**	**2.080**	**2.319**	**1.597**	**1.538**
29	***1997***	2.031	3.947	1.473	2.684	1.760	1.925
	1998	3.855	2.510	3.638	1.066	2.856	2.649
	1999	3.703	4.946	3.559	4.964	3.757	3.620
	2000	1.732	4.021	1.735	5.076	2.563	2.762
	2001	3.934	1.333	3.930	0.130	2.977	2.718
	2002	0.892	2.991	0.994	4.339	1.899	2.115
	2003	0.848	0.049	0.880	(0.192)	0.683	0.837
	2004	4.350	1.225	4.454	0.196	3.554	3.523
	2005	5.107	6.114	4.870	5.666	4.756	4.716
	2006	1.353	3.098	1.631	4.961	2.644	2.594
	2007	6.055	1.150	6.667	1.255	5.931	5.913
	2008	4.564	4.980	5.397	8.359	5.481	5.640
	2009	1.525	6.464	0.694	5.537	1.752	1.890

	2010	4.849	2.370	5.143	2.366	4.598	4.496
	mean	**3.200**	**3.228**	**3.219**	**3.315**	**3.229**	**3.243**
	std	**1.743**	**1.948**	**1.960**	**2.606**	**1.533**	**1.487**
30	***1997***	2.949	4.864	2.390	3.601	2.677	2.842
	1998	5.862	4.517	5.645	3.073	4.863	4.656
	1999	4.960	6.203	4.816	6.222	5.014	4.877
	2000	3.079	5.368	3.082	6.423	3.910	4.109
	2001	4.931	2.330	4.928	1.127	3.974	3.715
	2002	2.109	4.208	2.211	5.556	3.116	3.332
	2003	3.025	2.226	3.057	1.985	2.860	3.014
	2004	6.477	3.352	6.581	2.323	5.681	5.650
	2005	5.864	6.871	5.627	6.423	5.513	5.473
	2006	4.400	6.145	4.678	8.008	5.691	5.641
	2007	8.962	4.057	9.574	4.162	8.838	8.820
	2008	6.681	7.097	7.514	10.477	7.598	7.757
	2009	3.242	8.181	2.411	7.254	3.469	3.607
	2010	7.686	5.207	7.980	5.204	7.435	7.334
	mean	**5.016**	**5.045**	**5.035**	**5.131**	**5.046**	**5.059**
	std	**2.019**	**1.759**	**2.292**	**2.593**	**1.896**	**1.851**
31	***1997***	2.773	4.688	2.214	3.426	2.501	2.666
	1998	5.856	4.511	5.639	3.067	4.857	4.650
	1999	5.434	6.677	5.290	6.696	5.488	5.351
	2000	3.563	5.852	3.566	6.907	4.394	4.593
	2001	5.955	3.354	5.952	2.151	4.998	4.739
	2002	2.853	4.952	2.955	6.301	3.860	4.076
	2003	4.109	3.310	4.141	3.069	3.944	4.098
	2004	6.051	2.927	6.155	1.897	5.255	5.224
	2005	6.058	7.066	5.821	6.617	5.707	5.667
	2006	3.114	4.859	3.392	6.722	4.405	4.355
	2007	7.976	3.071	8.588	3.176	7.852	7.834
	2008	6.325	6.741	7.158	10.121	7.242	7.401
	2009	2.036	6.975	1.205	6.048	2.263	2.401
	2010	5.460	2.981	5.754	2.978	5.209	5.108
	mean	**4.826**	**4.855**	**4.845**	**4.941**	**4.855**	**4.869**
	std	**1.737**	**1.580**	**2.017**	**2.420**	**1.534**	**1.489**
32	***1997***	4.383	6.298	3.824	5.036	4.111	4.276
	1998	6.796	5.451	6.579	4.007	5.797	5.590
	1999	7.174	8.417	7.031	8.436	7.228	7.092
	2000	4.893	7.182	4.896	8.237	5.724	5.923

	2001	7.446	4.844	7.442	3.641	6.488	6.229
	2002	3.993	6.092	4.095	7.441	5.000	5.216
	2003	3.919	3.120	3.951	2.880	3.754	3.908
	2004	7.571	4.447	7.675	3.417	6.776	6.744
	2005	6.588	7.596	6.351	7.147	6.237	6.197
	2006	3.764	5.509	4.043	7.372	5.055	5.005
	2007	9.226	4.321	9.838	4.426	9.102	9.084
	2008	6.405	6.821	7.238	10.201	7.322	7.481
	2009	3.856	8.795	3.025	7.868	4.083	4.221
	2010	7.740	5.261	8.034	5.258	7.489	7.388
	mean	**5.982**	**6.011**	**6.002**	**6.098**	**6.012**	**6.025**
	std	**1.804**	**1.625**	**2.024**	**2.272**	**1.526**	**1.461**
33	***1997***	1.672	3.587	1.113	2.325	1.400	1.565
	1998	4.175	2.830	3.958	1.386	3.176	2.969
	1999	3.803	5.046	3.660	5.065	3.857	3.721
	2000	2.092	4.381	2.095	5.436	2.923	3.122
	2001	4.045	1.443	4.041	0.240	3.087	2.828
	2002	0.912	3.011	1.014	4.360	1.919	2.135
	2003	1.098	0.299	1.130	0.059	0.933	1.087
	2004	4.800	1.676	4.904	0.646	4.004	3.973
	2005	4.417	5.425	4.180	4.976	4.066	4.026
	2006	1.443	3.188	1.722	5.051	2.734	2.684
	2007	8.125	3.220	8.737	3.325	8.001	7.983
	2008	4.374	4.790	5.207	8.170	5.291	5.450
	2009	0.835	5.774	0.004	4.847	1.062	1.200
	2010	5.489	3.010	5.783	3.007	5.238	5.137
	mean	**3.377**	**3.406**	**3.396**	**3.492**	**3.407**	**3.420**
	std	**2.119**	**1.581**	**2.373**	**2.351**	**1.916**	**1.867**
34	***1997***	4.019	5.935	3.461	4.672	3.748	3.913
	1998	6.883	5.537	6.666	4.094	5.883	5.677
	1999	6.191	7.434	6.047	7.452	6.245	6.108
	2000	4.500	6.789	4.502	7.844	5.331	5.529
	2001	7.202	4.601	7.198	3.398	6.244	5.985
	2002	3.410	5.509	3.512	6.857	4.417	4.633
	2003	3.735	2.937	3.768	2.696	3.570	3.724
	2004	7.158	4.033	7.261	3.003	6.362	6.331
	2005	6.275	7.282	6.037	6.834	5.924	5.884
	2006	3.410	5.155	3.689	7.019	4.701	4.652
	2007	9.032	4.128	9.645	4.233	8.909	8.891

	2008	6.241	6.658	7.074	10.037	7.159	7.318
	2009	3.353	8.292	2.521	7.365	3.580	3.718
	2010	6.756	4.278	7.051	4.274	6.505	6.404
	mean	**5.583**	**5.612**	**5.602**	**5.698**	**5.613**	**5.626**
	std	**1.814**	**1.538**	**2.040**	**2.202**	**1.512**	**1.446**
35	***1997***	3.524	5.440	2.966	4.177	3.253	3.418
	1998	6.118	4.773	5.901	3.329	5.119	4.912
	1999	5.766	7.009	5.622	7.027	5.820	5.683
	2000	3.875	6.164	3.878	7.219	4.706	4.905
	2001	6.317	3.716	6.313	2.513	5.360	5.101
	2002	2.695	4.794	2.797	6.142	3.702	3.918
	2003	3.191	2.392	3.223	2.151	3.026	3.180
	2004	6.053	2.928	6.157	1.899	5.257	5.226
	2005	5.580	6.587	5.343	6.139	5.229	5.189
	2006	3.066	4.811	3.344	6.674	4.357	4.307
	2007	7.628	2.723	8.240	2.828	7.504	7.486
	2008	6.557	6.973	7.390	10.353	7.474	7.633
	2009	3.348	8.287	2.517	7.360	3.575	3.713
	2010	5.912	3.433	6.206	3.430	5.661	5.559
	mean	**4.973**	**5.002**	**4.993**	**5.089**	**5.003**	**5.016**
	std	**1.609**	**1.825**	**1.847**	**2.529**	**1.385**	**1.334**
36	***1997***	4.332	6.247	3.773	4.985	4.060	4.225
	1998	6.055	4.710	5.838	3.266	5.056	4.849
	1999	6.293	7.536	6.150	7.555	6.347	6.210
	2000	4.222	6.511	4.225	7.566	5.053	5.252
	2001	6.484	3.883	6.481	2.680	5.527	5.268
	2002	4.382	6.481	4.484	7.830	5.389	5.605
	2003	3.278	2.479	3.310	2.238	3.113	3.267
	2004	6.590	3.466	6.694	2.436	5.794	5.763
	2005	7.777	8.785	7.540	8.336	7.426	7.386
	2006	4.493	6.238	4.771	8.101	5.784	5.734
	2007	9.475	4.570	10.087	4.675	9.351	9.333
	2008	6.684	7.100	7.517	10.480	7.601	7.760
	2009	2.535	7.474	1.704	6.547	2.762	2.900
	2010	6.049	3.570	6.343	3.567	5.798	5.697
	mean	**5.618**	**5.646**	**5.637**	**5.733**	**5.647**	**5.661**
	std	**1.852**	**1.866**	**2.113**	**2.653**	**1.739**	**1.700**